Vol 3

# MEMOIRS

OF THE

# CARNEGIE MUSEUM

## VOL. VIII

(1919-1921)

W. J. HOLLAND, EDITOR



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# PREFATORY NOTE

The three Memoirs bound up in this volume were issued at the following dates: No. 1, December 17, 1919; No. 2, on February 24, 1921, although it came off of the press in December, 1920; and No. 3, on June 24, 1921. The delay in the issue of the second Memoir was due to causes over which the Editor had no control, and must be charged to the irregularity existing at that time in the railway service. Though the work had been printed and the separates bound in paper and shipped, there was nearly two months' delay in their delivery.

The first Memoir in this volume is from the pen of Dr. Arnold E. Ortmann, whose painstaking studies upon the *Naiades* of Pennsylvania, and especially upon those species which exist in the tributaries of the Ohio and Mississippi, have won for him a commanding position in this field of research. The collections made by him in the drainages of the Ohio and the various other eastern affluents of the Mississippi are undoubtedly the most complete now extant in any Museum. He also thoroughly explored all the streams of Pennsylvania belonging to the Atlantic watershed and those farther south including the Roanoke River. In the preparation of this Memoir Dr. Ortmann also consulted the typical collections, which are preserved in the Academy of Natural Sciences in Philadelphia and in the National Museum in Washington, in which are the types of the species named by Say, Rafinesque, Conrad, and Lea. Through the obliging kindness of Dr. Bryant Walker, and Mr. L. S. Frierson, Dr. Ortmann had access to authentic material representing species named and determined by these authors.

As I have elsewhere taken occasion to point out, the exploration of the streams of Pennsylvania and the adjacent States occurred "at the eleventh hour." So great and so rapid has been the pollution of the streams of the Atlantic seaboard and of the rivers of the middle west, that, had not Dr. Ortmann set out fifteen years ago to determine the molluscan content of these streams, we would have nothing but tradition to guide us. It is no exaggeration to say that not only have the fishes and mussel-shells in most of these streams become extinct, but in long reaches of the rivers all animal life has been totally destroyed. Throughout the bituminous coal-regions, where mine-water charged with sulphuric acid, due to the decomposition of pyrites, has been permitted to enter the streams, the waters, which once were clear

as crystal, flow blood-red, and not even an amœba can live in it. No more horrible illustration of the ignorance and improvidence of the citizens of the United States in dealing with great economic problems could be found. The Ohio River, "La Belle Rivière" of the French explorers, has become a wide sewer, into which, under our benevolent, farseeing, and wise Governments, the filth and vileness of hundreds of towns and cities, the contaminating water of thousands of mines, and the sewage of tens of thousands of cesspools and barn-yards is now being discharged in a nasty mass of corruption. "At the very nick of time," it was resolved, before it might be too late, to secure collections representing the fluviatile life of the State of Pennsylvania. This has been done. It cannot be done again, for, where we began fifteen years ago to collect shells from the rivers, there is now not a single shell to be found. In the spring of 1906 Dr. Ortmann made a collection of shells in the waters of the Ohio River south of Neville Island, opposite Coraopolis, where, as shown by the explorations of Mr. Rhoads at a somewhat earlier date, mussel-shells of numerous species were extremely abundant. In the following year Dr. Ortmann took a party of scientific friends to the locality to show them where the shells might be found and how rich the spot was in species. To his utter chagrin, not a living specimen could be secured. All that remained were dead shells, gaping wide. Since then the barge-men have excavated the sand and gravel, in which these creatures once lived, and even their habitat has been destroyed.

The second Memoir is from the pen of Dr. O. E. Jennings. It has been reviewed with most favorable comment by leading students of paleobotany. It is a fine example of the manner in which a botanist and student of vegetable ecology, familiar with the extant flora, may address himself to the interpretation of an extinct flora.

The third Memoir, upon the Mussel-shells of the South American Continent, is again from the pen of Dr. A. E. Ortmann. The Carnegie Museum is fortunate in possessing without doubt the largest collection of the mussel-shells of South America preserved with the soft parts. This collection was mainly made through the labors of Mr. John D. Haseman on the occasion of the Carnegie Museum Expedition to Central South America. While the Carnegie Museum does not as yet possess specimens of all of the species, which in former times have been described by those who have written upon the mussel-shells of South America, and much remains to be done in this field, Dr. Ortmann has had more material representing the animals which inhabit the shells than any other author who has ever written upon this theme. One of the most interesting results of his research is the confirmation of the affinity of numerous South American forms with those of Africa and of Australia.

From whatever angle we approach the study either of the fauna or the flora of South America, we arrive at the confirmation of the view, which has already long been maintained, that this Southern continent must, at one time, have been connected with Africa and with Australia.

W. J. Holland.

Carnegie Museum,
June 2, 1921.

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P. 106. Fig. 11, for "*Elliptis*" read *Elliptio*.

P. 418. Fifteenth line from top, for "*Daphnes*" read *Daphnea*.

P. 426. Twelfth line from bottom, for "*Vaccinum*" read *Vaccinium*.

*Publications of the Carnegie Museum, Serial No. 104.*

# MEMOIRS

OF THE

# CARNEGIE MUSEUM.

VOL. VIII. NO. 1.

W. J. HOLLAND, EDITOR.

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# A MONOGRAPH OF THE NAIADES OF PENNSYLVANIA. PART III
# SYSTEMATIC ACCOUNT OF THE GENERA AND SPECIES

By ARNOLD E. ORTMANN, PH.D., SC.D.

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PITTSBURGH.
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# MEMOIRS

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# CARNEGIE MUSEUM.

VOL. VIII. No. 1.


## A MONOGRAPH OF THE NAIADES* OF PENNSYLVANIA. PART III. SYSTEMATIC ACCOUNT OF THE GENERA AND SPECIES.[1]


BY ARNOLD E. ORTMANN, PH.D., SC.D.


(PLATES I–XXI.)

### INTRODUCTORY.

In the first part of this monograph (Ortmann, 1911*b*),[2] certain anatomical features hitherto but little investigated were considered (*l. c.*, Pt. I, p. 282 ff.), and their bearing upon the rearrangement of the system of the Naiades was discussed in Part II (*l. c.*, pp. 322 ff.). At the end of Part II, a key for the genera was attempted (pp. 335–338). Since then additional material, chiefly representing

* In Parts I and II of this Monograph, which appeared in the Memoirs of the Carnegie Museum, Vol. IV, No. 6, I employed the term *Najades*, following the usage of certain well-known authors who have written upon this group. The spelling of this word given by Lamarck, who first employed it, was *Nayades*, and this would have priority according to a strict application of the laws governing nomenclature, were it not for the fact that the Lamarckian term plainly is an error in transcription from the original Greek, which is Ναϊάδες. I, believe that when a Greek word is used it ought to be transcribed as nearly as possible in conformity with philological usage, and therefore have reverted to the form *Naiades*, which is not only good Greek, but sanctioned by the usage of a multitude of other authors. The chief end of the "law of priority" is not to preserve and perpetuate mistakes in spelling, even when made by men as eminent as Lamarck.

[1] This paper is in continuation of the papers published in the Memoirs of the Carnegie Museum, Vol. IV, No. 6, 1911.

[2] The references given in the text refer to the bibliography at the end of this paper.

such forms as are not found in Pennsylvania, has been secured and studied. This made necessary a number of changes, which chiefly affect the division into genera, and which have been published (Ortmann, 1912). The system proposed in this latter paper will be used in the following pages with such corrections as have become inevitable in the course of still further studies.

With regard to the systematic literature, I have refrained from giving a full list of references and synonyms under each species, since the citations given by Simpson (1914) are as complete as could be desired. The quotation of the earlier reports from Pennsylvania was deemed desirable, in order to get an idea of the advance made in recent years in our knowledge of the subject.

## Family **MARGARITANIDÆ** Ortmann (1911).

Ortmann, 1911*a*, p. 129; 1911*b*, p. 334; 1912, p. 223.

### Genus Margaritana Schumacher (1817).

Ortmann, 1912, p. 230; Simpson, 1914, p. 511.

Type *Mya margaritifera* Linnæus.

### 1. **Margaritana margaritifera** (Linnæus) (1758).

*Margaritana margaritifera* (Linnæus) Simpson, 1914, p. 513.

Plate I, fig. 1.

*Records from Pennsylvania:*

Lea, Obs. II, 1838, p. 56, and VII, 1860, p. 225. As to the correctness of these records, see below.
Hartman & Michener, 1874, p. 91. See also below.
Conner, 1904, p. 91 (Still Creek, Quakake).
Ortmann, 1909*b*, p. 208.

*Characters of shell:* Shell large and heavy, cylindric-ovate, elongate, often arcuate when old. Anterior end rounded, posterior produced. Beaks very little elevated. Epidermis blackish or blackish brown. Nacre whitish, pinkish, or somewhat purplish, posteriorly iridescent. Pseudocardinal teeth present, laterals obsolete, generally entirely wanting. Inside of the mantle-line a number of small muscle-scars.

*Size:* My largest specimen (from Rene Mont) measures: L. 152 mm.; H. 67 mm.; greatest D. 49 mm. This is larger than any of the previous records. The maximum length given by Carl (1910, p. 65) for the form found in the Odenwald, Germany, is 136 mm. Israël (1910, p. 177) gives 140 mm. for the form from the Elster-drainage in Germany.

*Soft parts* and *glochidia* (See Ortmann, 1912, p. 230, fig. 1; and 1913*b*, p. 89). In the American form, the glochidia have not yet been observed. The fine teeth on the lower margin are present only in fully mature glochidia.

The *breeding season* in Pennsylvania occurs in the period from June to August (Conner, 1909, p. 112); in Europe it occurs from the middle of July to August (Harms, 1907, p. 818; Carl, 1910, p. 16).

*Remarks:* There is no possibility of mistaking this species, for it is sharply characterized by size (being the largest shell of the Atlantic-drainage), shape, color, hinge, and by its peculiar station. Compared with the same species from other localities, the Pennsylvanian specimens are remarkable for their size, being the largest ever recorded. I cannot see any differences between them and specimens from New England and Newfoundland. European shells likewise perfectly agree with them. Specimens from the Pacific slope are all considerably smaller and comparatively thinner, and the color of the nacre inclines more toward purplish tints. There are also slight differences in the hinge. This western form has been distinguished as a variety (*falcata* Gould).

*Localities represented in the Carnegie Museum:* [3]

Locust Creek, Tamaqua; Cold Run, Hecla; Indian Run, Rene Mont; all in Schuylkill Co., Pennsylvania.

Westfield, Hampden Co. (Hartman collection); Amherst, Hampshire Co., Massachusetts (Holland collection).

Amy Brook, Henniker, Merrimack Co., New Hampshire (G. H. Clapp).

Cape Elizabeth, Cumberland Co. (G. H. Woods); Aroostook River, Caribou, and Little Madawaska River, New Sweden, Aroostook Co., Maine (O. O. Nylander).

South West River, Belvoir Bay (Hare Bay), Newfoundland (G. H. Clapp).

*From Europe* (all received from W. Israël):

Perl Bach, Postfelden near Falkenstein, and Perlbach, Rehau above Hof, Bavaria; Goernitzbach, Oelsnitz, Saxony; Aumabach, Rohna, Saxe-Weimar; Steinach, Sonneberg, Saxe-Weimar; Ulfenbach, Affolterbach, Hesse, Germany.

*From the Pacific slope* (var. *falcata* Gould):

Long Valley, Lake Co., California (Hartman collection); Chehalis River, Porter, Chehalis Co. (H. Hannibal); Seattle (P. B. Randolph), and Ravenna Park, Seattle, King Co., Washington (H. Hannibal).

*Distribution and Ecology in Pennsylvania* (See fig. 1): This species has been recorded by Lea from Crum Creek, Delaware Co., and by Hartman & Michener from White Clay Creek, Chester Co. Lea also says that it goes southward only as far as middle Pennsylvania. I have expressed (1909*b*) my doubts as to the correctness of these two localities, and must maintain them most emphatically. In White Clay Creek I have collected myself, and found only the common fauna of the Atlantic streams, and *Margaritana* is not found where this is present, according to my experience.

[3] When not otherwise indicated, the specimens have been collected by myself.

The first to report an exact locality for this species in Pennsylvania was Conner (1904) Still Creek, at Quakake, Schuylkill Co. This creek is not named on the sheets of the U. S. Topographic Atlas, but it is, as I have ascertained, a tributary of the uppermost Little Schuylkill, and the place Quakake is no doubt the same as Quakake Junction, not far from Tamaqua. In the same general region, near Tamaqua, this species once used to be abundant in the headwaters of the Little Schuylkill, and its metropolis was in Locust Creek (See fig. 1) but the

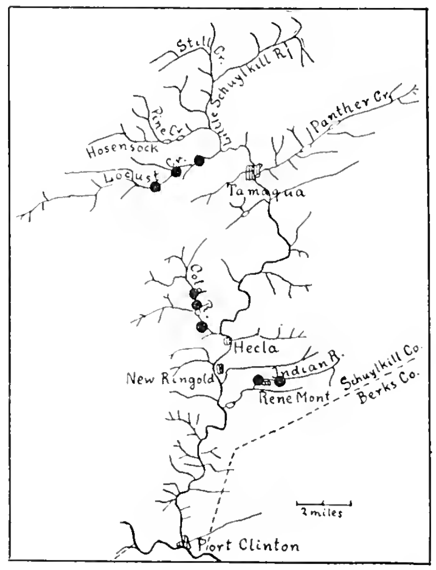


FIG. 1.
Glacial Preserve of *Margaritana margaritifera* in Pennsylvania.

recklessness of the pearl-hunters has nearly exterminated it. At the present time living specimens are rare in Locust Creek. The natives also report that it used to be found in Pine and Hosensock Creeks.

This species also occurs to the South of Tamaqua, in tributaries of the Little Schuylkill, in Cold Run, above Hecla, and in Indian Run, at Rene Mont. The latter locality marks the southernmost extension of the range of the species. Other creeks in this region also may have formerly contained this shell, but, as for instance in the case of Panther Creek, it must have been destroyed long ago by the pollution from the coal-mines.

The headwaters of the Little Schuylkill in Schuylkill County appear to be the only region in Pennsylvania where this species is found. It has never been reported from any other part of the state (except the spurious records mentioned above), and the efforts of myself, of Conner, and of Pilsbry to locate it elsewhere have only proved its absence. The writer devoted much time to hunting for it, or to securing information about its presence, in northern Schuylkill County, in

the upper Lehigh-drainage, in the Pocono Mountains, and in the region of the North Branch of the Susquehanna, but without success.

In the upper Little Schuylkill-drainage this species lives in mountain streams with cold water (trout-streams) at an elevation of 800 feet and more above sea-level. The sources of these streams are at about 2000 feet, and the greatest number of shells is found at about 1000 to 1200 feet. These streams are rough and full of little falls and rapids. The shell prefers eddies and pools which are rather deep, with a steady and lively current, and with gravelly and sandy bottoms. Sometimes these shells are found in sandy (but not muddy) bottoms of mill-ponds in quiet water, but they probably have been washed down into these. Cold water with lively currents seems to be essential, and also shade, for I chiefly found specimens in places where the banks of the streams were wooded, and not where they ran through open fields. The characteristic shrub in these woods is *Rhododendron maximum*, and besides *Alnus*, *Carpinus*, and often *Tsuga*.

In Europe it has been observed that *Margaritana* is missing in streams which run over limestone rocks, and that it is very impatient of water which holds lime (Haas, 1910, p. 109). The same is true in this country. All the streams in Schuylkill County in which it lives run over sandstones and shales. Indian Run is entirely in the Devonian Clinton Shales, while Cold Run and the more northern streams are in the Lower Carboniferous Mauch Chunk Shales, the boulders in the water-courses being formed by sandstones and conglomerates of the overlying Pottsville beds.[4]

The headwaters of the Little Schuylkill form a perfectly isolated station for this species, about one hundred miles away from the nearest locality, which is to the North, in Rockland County, in southern New York. The Pennsylvanian area of this species is not only the most southern extension of its range in eastern North America, but it also has the peculiarity of being the only one to the South of the Terminal Moraine. Thus it may be regarded as a part of the Glacial Preserve (*refugium*) of this species (See Ortmann, 1913*a*, pp. 377 ff.). *Margaritana margaritifera* in Pennsylvania is a fine example of a Glacial Relic.[5]

[4] In this connection I should mention that O. O. Nylander, who sent me specimens from the Aroostook River, Maine, states positively that the formation is Aroostook Limestone (Silurian. *Cf.* Williams, H. S., & Gregory, H. E., in *Bull. U. S. Geol. Surv., 165*, 1900, pp. 44 and 141). This matter, however, should be investigated more carefully.

[5] Subfossil shells of *Margaritana margaritifera* have been found in Hartman's Cave, near Stroudsburg, Monroe Co., Pa., associated with shells of *Elliptio violaceus* (*Unio complanatus*), bones of living and extinct vertebrates, and with human implements of stone, bone, and horn (See Leidy, 1889). I have seen, in the Philadelphia Academy of Natural Sciences, a left valve taken from Hartman's Cave, which undoubtedly is this species. This locality is *within* the glaciated area, and thus these remains are surely

*General Distribution:* This species is found, outside of North America, in northern and middle Europe, northern Asia, and Japan (Simpson, 1900, p. 677).[6] With regard to this, we do not need to go into detail here. Its North American distribution recently has been discussed by Walker (1910*a*, p. 140, pl. 2), and a careful list of localities has been given, to which we should add, however, a few new localities represented in the Carnegie Museum (see above), and further Buckfield, Oxford Co., Maine (Allen, J. A., in *Nautilus*, XXV, 1912, p. 120) (See also Nylander, 1914).

I do not think that *Margaritana margaritifera* is of North American origin, as represented by Scharff (1912, p. 51), but I believe that it reached eastern North America by the North Atlantic land-bridge, coming from Europe (See Scharff, *ibid.*). I also hold the opinion of Scharff that there were other places of survival during the Glacial time, either within the drift area, or close to its eastern edge, on the former eastward extension of the continent.

## Family **UNIONIDÆ** (D'Orbigny) Ortmann (1911).

Ortmann, 1911*a*, p. 129; 1911*b*, p. 335; 1912, p. 223.

### Subfamily UNIONINÆ (Swainson) Ortmann (1910).[7]

Ortmann, 1910, p. 116; 1911*a*, p. 129; 1911*b*, p. 335; 1912, p. 224.

KEY TO THE GENERA.

$a_1$. All four gills serving as marsupia. Mantle connection between anal and supra-anal openings present, short, and deciduous.

$b_1$. Placentæ subcylindrical, rather persistent, often red. Shell smooth, without sculpture upon the disk. Beak-sculpture simple, concentric, and poorly developed. . . . . . . . . *Fusconaia.*

$b_2$. Placentæ lanceolate and compressed, not very persistent, whitish, or yellowish, but not red.

postglacial. This would indicate, possibly, a very early step in the postglacial dispersal of this species, provided these shells are actually from the neighborhood of this cave, and have not been carried there by man from a long distance. At present, *Margaritana* is not found in this region. I have hunted for it in vain in Broadhead Creek at Henryville (above Stroudsburg), and have received the assurance from competent persons that nothing resembling this shell is found in the trout-streams within a radius of at least fifty miles from Henryville.

[6] It also has been reported from Iceland, but this has been questioned. The Carnegie Museum has received from W. Israël a specimen labeled "Reykjavik, Iceland." After correspondence with Israël and Stejneger (in Washington), and by Stejneger with parties in Copenhagen, there remains no doubt that this specimen is to be traced back to a dealer in Copenhagen, who tried to impose upon a number of conchologists. He even claimed that the specimens in question were collected by Mrs. Israël in 1863, before she was born!

[7] This subfamily cannot be credited to v. Ihering (1901, p. 53) since he used the name in an entirely different sense.

Shell with sculpture upon the disk (ridges or tubercles). Beak-sculpture concentric, double-looped or zig-zag.

$c_1$. Chief sculpture upon disk consisting of a few oblique, strong undulations. Beak-sculpture concentric. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Amblema.*

$c_2$. Chief sculpture on disk consisting of tubercles and warts. Beak-sculpture concentric, double-looped, or zig-zag. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Quadrula.*

$a_2$. Only the two outer gills serving as marsupia.

$b_1$. Shell more or less tubercular upon the disk.

$c_1$. Beak-sculpture well-developed, consisting of numerous wavy ridges. Nacre dark purplish. Soft parts whitish. No supra-anal. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Rotundaria.*

$c_2$. Beak-sculpture rudimentary, consisting of a few obscure, concentric bars. Nacre light-colored. Soft parts generally pale orange. Supra-anal present. . . . . . . . . . . *Plethobasus.*

$b_2$. Shell smooth upon disk, without tubercles.

$c_1$. Shell rather thick and solid, short and high, sometimes drawn out posteriorly, and then distinctly cuneiform and oblique. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Pleurobema.*

$c_2$. Shell generally not very thick, often rather thin, not short and high, but more or less elongated, and not oblique. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Elliptio.*

## Genus Fusconaia Simpson (1900).

Ortmann, 1912, p. 240; Simpson, 1914, p. 865 (as section of *Quadrula*).

Type *Unio trigonus* Lea (= *F. flava trigona*).

### Key to the Species and Varieties.

$a_1$. Shell without a distinct posterior ridge, disk rather uniformly convex. Color brownish, or blackish brown.

$b_1$. Diameter of shell fifty percent of length, or more. . . . . . . . . . . . . . . . . . . . . . . . . . . . *F. subrotunda.*

$b_2$. Diameter of shell less than fifty percent of length. . . . . . . . . . . . . . . . . *F. subrotunda kirtlandiana.*

$a_2$. Shell with a distinct posterior ridge, disk flattened, or even slightly concave in front of the ridge. Color lighter, more reddish or yellowish brown.

$b_1$. Shell attaining a good size. Growth-lines irregular.

$c_1$. Diameter of shell less than fifty-five percent of length. . . . . . . . . . . . . . . . . . . . . . . . . *F. flava.*

$c_2$. Diameter of shell fifty-five percent of length or more. . . . . . . . . . . . . . . . . . . . *F. flava trigona.*

$b_2$. Shell much smaller. Diameter very variable, but mostly considerable. Growth-lines very distinct and regular. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *F. flava parvula.*

## Fusconaia subrotunda (Lea) (1831).[8]

*Quadrula subrotunda* (Lea) Simpson, 1914, p. 892.

Plate I, fig. 2.

*Records from Pennsylvania:*

Harn, 1891, p. 137 (western Pennsylvania).

Clapp, 1895, p. 116 (*U. pilaris* from Allegheny County is undoubtedly this).

[8] This should not be called *F. sintoxia* (Rafinesque), although Vanatta (1915, p. 558) identifies Rafinesque's species with it. According to the measurements given by Vanatta, the diameter of Rafinesque's *sintoxia* is forty-three percent of the length; and thus it could only fall under *kirtlandiana.* But since the nacre is described as rose-colored, this does not seem likely since *subrotunda* and *kirtlandiana* have not rose-colored nacre.

Rhoads, 1899, p. 136, has recorded specimens of this species under *U. obliquus* from Coraopolis, Allegheny Co., and Beaver, Beaver Co.
Ortmann, 1909*b*, p. 200.

*Characters of Shell:* Shell large and heavy, swollen, the diameter amounting to fifty percent of the length or more, subcircular or ovate; when old, often oblique and drawn-out at the lower posterior end. No posterior ridge. Beaks moderately prominent. Beak-sculpture not distinctly observed, but probably weakly developed and concentric. Epidermis in young specimens light brown, almost yellow, with more or less distinct dark rays, which often appear as bundles of fine lines, and frequently break up into squarish spots, and with dark concentric growth-lines. In older specimens the epidermis turns darker, brown to blackish, and becomes nearly uniform without any rays.

Hinge-teeth heavy, pseudocardinals divergent in the young, becoming very heavy, and subparallel to the laterals, in old shells. Interdentum variable, but generally very wide, and beak-cavity very deep and compressed. Nacre always whitish.

| | L. | H. | D. | Pr.ct. |
|---|---|---|---|---|
| *Size:* Industry, Cat. No. 61.3938*a*................ | 107 mm. | 81 mm. | 53 mm. | .50 |

This is the largest specimen at hand. It fairly represents the average in outline, but the diameter has been unduly lowered by the production of the posterior end.

*Soft parts* and *Glochidia* (See Ortmann, 1912, p. 244).

*Breeding season:* Tachytictic form, breeding in June and July (Ortmann, 1909*a*, p. 101). Gravid females have been found on the following dates: June 22, 1909; June 24, 1909; July 3, 1908; July 11, 1911; July 5, 1909; July 13, 1908. Glochidia as well as eggs were found on July 5 and 13; on the other dates, eggs only.[9] The discharge of placentæ was observed in a few cases as early as June 24 (Ortmann, 1911*b*, p. 306), but this was in captivity, and was certainly premature.

*Remarks:* This is one of our heaviest and largest shells. Its external characters are rather indifferent, and it resembles several other species, with which it is easily confounded. In general the subcircular or oval outline, with rather evenly curved margins, and the deep, compressed beak-cavities characterize it. *Pleurobema obliquum catillus* comes very near to it, however, but this form is mostly more triangular, with the lower margin more nearly approaching a straight line, and with a more distinct lower posterior angle. It has only a rather shallow, and not a compressed, beak-cavity. Of course the characters of the

[9] Of the form from Elk River, West Virginia (var. *leucogona* Ortmann, 1913*b*, p. 89) I found gravid females as early as May 25, 1911, and as late as July 10, 1911.

soft parts are entirely different, and, when females are at hand, there is no mistake possible. The soft parts of *F. subrotunda* are often of the orange type, of *Pleurobema obliquum* never. Specimens with red nacre are always *obliquum*-forms, and never *subrotunda*.

There is no difference whatever between the sexes in the shell of this species. The differences between it and var. *kirtlandiana* will be discussed under the latter.

Much confusion prevails as to this species, and it has often been misidentified, probably because originally only the young was described, and no good figures of the old shell were published. The synonymy given by Simpson seems to be correct, but I think that the following reference should be added: *Unio varicosus* Lea (Obs. I, 1834, pl. 11, fig. 20, Ohio River). Lea compares this with *Plethobasus cyphyus* (= *æsopus*), and Simpson (1900, p. 765) identifies it with *Plethobasus cicatricosus* (Say). Lea's figure would stand very well for an old *Fusconaia subrotunda,* except for its color, which is too light, but I have several old specimens with a rather light (brown) epidermis, although not as light as in this figure. The color of Lea's *varicosus* is all that agrees with *Pleurobema cicatricosus.* According to specimens of the latter in the Carnegie Museum, and the figures of Reeve (1864, Pl. 8, fig. 31, and Pl. 13, fig. 50), the character of the concentric ridges of the shell is entirely different from that in Lea's figure. Furthermore the shape of the latter is not at all the characteristic shape of *cicatricosus.* The specific name *varicosus* would have priority (1829) over *subrotundus,* but cannot be used, since it is pre-occupied by *U. varicosus* Lamarck, 1819, now *Alasmidonta varicosa.*

*Localities in Pennsylvania, represented in the Carnegie Museum:*

Ohio River, Cooks Ferry, Shippingport, Industry, Beaver Co.; Coraopolis (S. N. Rhoads) and Neville Island, Allegheny Co.

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).

Mahoning River, Mahoningtown, Lawrence Co.

Allegheny River, Aladdin, Godfrey, Johnetta, Kelly, Armstrong Co.

Monongahela River, Westmoreland Co. (G. A. Ehrmann), and Charleroi, Washington Co. (G. A. Ehrmann).

Cheat River, Cheat Haven, Fayette Co.

*Other localities, represented in the Carnegie Museum.*

Ohio River, Toronto, Jefferson Co., Ohio; St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.

Tuscarawas River, Ohio (Holland collection).

Levisa Fork of Big Sandy River, Prestonsburg, Floyd Co., Kentucky.[10]

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).[11]

[10] Only one specimen found by myself. It has the diameter of fifty percent, and thus belongs here, but stands close to the var. *kirtlandiana.*

[11] These specimens do not differ from the general run of the form from the Ohio. In the upper

*Distribution and Ecology in Pennsylvania* (See fig. 2): This species belongs in Pennsylvania to the larger rivers, the Ohio, Allegheny, and Monongahela, to the Beaver as far as the lower Mahoning, and to the lower Cheat. It has never been found in any other tributary of the upper Ohio system. It prefers heavy shingle and gravel, in a strong current, and is especially adapted to this habitat by its

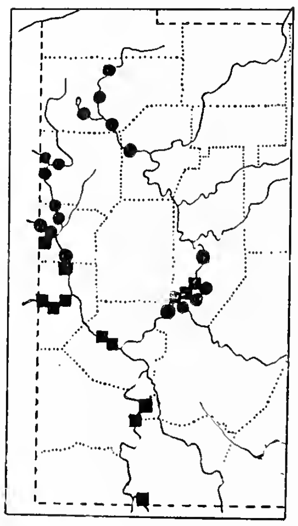

Fig. 2.

■ *Fusconaia subrotunda.*
● *Fusconaia subrotunda kirtlandiana.*

subglobular shape and heavy shell. In the Allegheny it occurs as high up as Kelly in Armstrong County; above this point, the river is largely polluted, so that the upper limit of its former distribution cannot be now ascertained, but it is positively missing in the upper Allegheny above Oil City, and is not represented by its variety *kirtlandiana*, while the latter takes its place in French Creek. In the upper parts of the Beaver-drainage it is also gradually replaced by *kirtlandiana*. Particulars about its range in the Monongahela are wanting, but it possibly reached a little beyond the West Virginia line. It is found in the lower Cheat, and has also been found in the Indian Garbage heap at Point Marion, opposite the mouth of the Cheat (See Ortmann, 1909*c*).

*General Distribution:*

*Type locality;* Ohio (Lea).

This species is positively known only from the Ohio-drainage, ranging from Pennsylvania westward to Illinois, and is generally restricted to the Ohio River

Tennessee region this species is represented by a dwarfed race, commonly called *U. pilaris* Lea. Also in Elk River, West Virginia, I have discovered a dwarfed race, which I have called var. *leucogona* (Ortmann, 1913*b*, p. 89), but I doubt now the propriety of distinguishing this by a name.

proper and some of its larger tributaries. Of the latter outside of Pennsylvania the Tuscarawas and Scioto Rivers contain it (Sterki, 1907*a*); it is in the Illinois River in Illinois (Baker, 1906). Call (1896*a*) does not mention this species from Indiana, but he unites it with *F. ebena* (Lea), and quotes this from the Ohio and Wabash. According to Blatchley & Daniels (1903) *subrotunda* is plentiful in the Wabash and Tippecanoe Rivers in Indiana. The form from Elk River in West Virginia (Big Kanawha-drainage) is slightly different (var. *leucogona*). Simpson (1900) cites the Cumberland and Tennessee river-systems, and Wilson & Clark (1914) confirm this for the Cumberland. Similar forms are, indeed, found in these rivers, but they generally go under different names (mostly *pilaris* Lea). Yet I have typical *subrotunda* from the Tennessee in northern Alabama. Its presence in the Big Sandy in Kentucky has been established.

All records from outside of this region are to be regarded for the present as doubtful, or positively wrong, as for instance, Grand River, Ontario, and Michigan. The records from Lake Erie given by Sterki (1907*a*, p. 391) and Ortmann (1909*b*, p. 203) do not refer to this species, but to *Pleurobema obliquum pauperculum*, and the same probably is true of Walker's record (1913, p. 22).

Toward the west and southwest, in the Mississippi-drainage, typical *subrotunda* is gradually replaced by the form or species *F. ebena* (Lea), which is, for instance, rather prevalent in the Ouachita River in Arkansas. The interrelation between *F. subrotunda* and *F. ebena* should be studied more closely especially in the lower Ohio and its tributaries.

### Fusconaia subrotunda kirtlandiana (Lea) (1834).

*Quadrula kirtlandiana* (Lea) Simpson, 1914, p. 891.

Plate I, figs. 3, 4, 5.

*Records from Pennsylvania:*

Harn, 1891, p. 137 (western Pennsylvania).
Rhoads, 1899, p. 137 (Beaver River, Wampum, Lawrence Co.).
Ortmann, 1909*b*, p. 201.

*Characters of variety:* Shell with the outline of *F. subrotunda*, but much more compressed, and with less prominent beaks. The diameter is less than fifty percent of the length, falling as low as thirty-three percent. In consequence of the compression, the posterior part of the shell, behind the beaks, appears more elevated, almost wing-like. Color of epidermis generally brighter, chiefly so in young shells, which often possess a very light yellowish ground-color, with darker, well-marked growth-rests, and distinct black or dark green rays. In the old shell,

the color becomes more uniformly brown, and sometimes blackish. All other characters are like those of the main form.

| | L. | H. | D. | Pr.ct. |
|---|---|---|---|---|
| *Size:* Clarksville, Cat. No. 61.3927 | 133 mm. | 97 mm. | 48 mm. | .36 (largest at hand). |
| Cochranton, Cat. No. 61.3923 | 128 " | 111 " | 51 " | .40 |

These specimens are superior in size to the largest *F. subrotunda.*

The *soft parts* and *glochidia* have been described and figured by Ortmann (1911*b*, Pl. 89, fig. 1, and 1912, p. 245).

*Breeding season:* The only gravid female ever found was obtained on August 2, 1908; it had glochidia. Among individuals collected June 25, 1907, and July 10 and 19, 1909, none were gravid, although a good many were obtained. This is rather astonishing. The one gravid specimen was the only one among a large number. Many have been collected later in the season, but no other gravid female has ever turned up.

*Remarks:* This form passes very gradually into *F. subrotunda,* and is positively recognized only by the compression of the shell. In order to distinguish these two forms I was compelled to introduce an artificial and arbitrary dividing line at the diameter of fifty percent of the length. Of course, this does not correspond to the natural conditions, but it is a wonderful help for the practical separation of the forms.

The other characters are also not reliable, although generally the color and the development of a posterior wing help in the identification.

The soft parts in *kirtlandiana* are more frequently of the whitish type, although the orange type is not rare.

In this form it is likewise impossible to distinguish males and females by the shell.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Ohio River, Industry, Beaver Co.; Coraopolis (S. N. Rhoads) and Neville Island, Allegheny Co. (W. F. Graham).

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).

Mahoning River, Mahoningtown, Coverts, Edinburg, Lawrence Co.

Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Sharpsville and Clarksville, Mercer Co.

Pymatuning Creek, Pymatuning Township, Mercer Co.

Allegheny River, Natrona, Allegheny Co.; Godfrey, Johnetta, Kelly, and Templeton, Armstrong Co.

French Creek, Utica, Venango Co.; Cochranton, Meadville, and Cambridge Springs, Crawford Co.

Conneaut Outlet, Conneautlake, Crawford Co.

Monongahela River, Charleroi, Washington Co. (G. A. Ehrmann).

Cheat River, Cheat Haven, Fayette Co.

*Other localities represented in the Carnegie Museum:*

Mahoning River, Ohio (Hartman collection) (Topotype).
Tuscarawas River, Ohio (Holland collection).
West Fork River, Lynch Mines, Harrison Co., West Virginia.
Little Kanawha River, Grantsville, Calhoun Co., West Virginia (W. F. Graham).

*Distribution and Ecology in Pennsylvania* (See fig. 2): The distribution of this form in Pennsylvania clearly indicates that it is the representative of *F. subrotunda* in the smaller rivers and creeks, but that it passes in the downstream direction into the latter, and is associated with it in the larger rivers. Its metropolis is in the Beaver system and French Creek. In these it is practically everywhere, and lives in coarser or finer gravel, even in sand, and in more or less rapidly flowing water. It avoids, however, the extreme headwaters, and is not found in the Shenango above Clarksville, and not in French Creek above Cambridge Springs. The records from some smaller tributaries (Pymatuning Creek and Conneaut Outlet) are founded upon single individuals.

In the larger rivers, the Allegheny, Monongahela, and Ohio, it is also present, but its place is gradually taken by the typical *F. subrotunda*. From Cooks Ferry in Beaver County down the Ohio to Portsmouth, Scioto County, Ohio, the typical form alone is present. Exceptionally large and posteriorly produced specimens may exhibit the dimensions of *kirtlandiana*, but such are very rare in this section of the river, and generally it is clearly evident that they were typical *subrotunda*, when young.

*General Distribution. Type locality*, Mahoning River, Ohio (Lea).

This variety appears to be restricted to the tributaries of the upper Ohio in West Virginia, Ohio, and Pennsylvania. The river which forms its type locality in Ohio also contains it in Pennsylvania, and it occurs also in the other branches of the same river-system (the Shenango and Beaver). I further have ascertained that it is found in French Creek, and the upper Monongahela, its range going down for some distance into the larger rivers. I also found it in the Little Kanawha in West Virginia.

Simpson (1900) quotes it from the " Ohio, Cumberland and Tennessee River systems, southwest to Arkansas, north to Wisconsin (?), east through southern Michigan." I think that this wide range is entirely erroneous. Looking over the literature we find it reported from Ohio (aside from the Mahoning River) from the Ohio itself and some of its tributaries, especially from the Tuscarawas River (Sterki, 1907*a*). Further it is mentioned from the Grand River in Michigan (Call, 1885, and Walker, 1892 and 1898), and from Waukesha, Waukesha Co.,

Wisconsin (Call, 1885). This latter locality is doubted by Simpson, and I believe that of all these localities only the Tuscarawas River is reliable.

Outside of the upper Ohio region positive and trustworthy records are absent. Thus, for instance, this shell is missing in the Cincinnati Catalogue of Harper (1896). Sterki's records from other parts of the state of Ohio are very vague. Call (1896*a*) does not mention it from anywhere in Indiana, and so forth. The Michigan record is founded upon Call's authority, and stands by the side of another one (Wisconsin), which is certainly in error.

Apparently this form has been frequently misunderstood, even by Simpson, and this is the more probable, since corresponding, but not entirely identical, forms are met with elsewhere. A flat form of *F. subrotunda* is found in Elk River, West Virginia. This I have distinguished as var. *leucogona* (Ortmann, 1913*b*, p. 89), but in the lower part of this river the connection with typical *subrotunda* recurs.

All this tends to show that *F. subrotunda* has the tendency in the headwaters of the Ohio to develop a flat form, called *kirtlandiana*, constituting an ecological race of the main species. I wish to call special attention to this; as we shall see further on that similar phenomena present themselves to view in the case of other species.

### Fusconaia flava (Rafinesque) (1820).

*Quadrula rubiginosa* (Lea) Simpson, 1914, p. 872; *Quadrula flava* (Rafinesque) Vanatta, 1915, p. 557; *Fusconaia flava* (Rafinesque) Utterback, 1916, p. 26.

Plate II, fig. 3.

*Records from Pennsylvania:* [12]

Clapp, 1895, p. 116 (Allegheny Co.).[13]
Rhoads, 1899, p. 137 (Ohio River, Coraopolis, Allegheny Co.).[13]
Ortmann, 1909*b*, p. 199.

*Characters of the shell:* Shell of medium size, but rather heavy. Outline subtrapezoidal. Beaks not very prominent, and not inflated. Beak-sculpture consisting of three to five subconcentric bars, slightly waved, forming an angle upon the posterior ridge, and most distinct there. Often these bars are quite

[12] Marshall (1895, p. 90) quotes this species from the Allegheny in Warren Co., but I consider this an error. Just this instance (and a few others) induce me to question the accuracy of the locality of some of the species recorded from Warren Co. I have repeatedly collected in this region, but did not find any evidence for the existence of this form.

[13] The localities in Allegheny Co. are in the region, where the transition from *flava* into *trigona* takes place. Some of Rhoads' specimens should be called *flava*.

indistinct, even on well-preserved beaks. The fourth and fifth bars are generally marked only by nodular swellings upon the posterior ridge.

Shell rather compressed; diameter less than fifty-five percent of length. Sides flattened, or even with a shallow depression in front of the posterior slope. The latter separated from the sides of the shell by a distinct posterior ridge. Ventral margin from straight to broadly and gently emarginate.

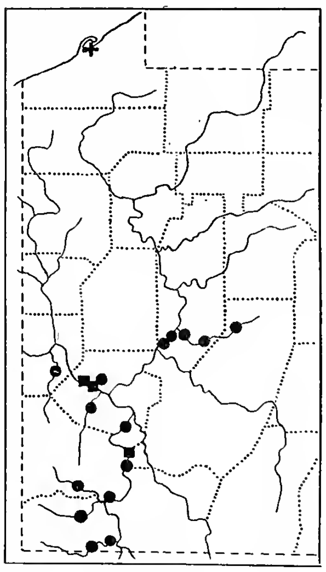

FIG. 3.
■ *Fusconaia flava trigona.*
● *Fusconaia flava.*
+ *Fusconaia flava parvula.*

Surface without sculpture. Epidermis rather light brown, or of a chestnut or russet hue, rarely showing some green, with fine, indistinct, greenish or brownish rays, and dark growth-rests. When older, the rays disappear, but the epidermis remains rather light, and only in very old shells turns dark brown or even blackish.

Hinge-teeth well-developed; pseudocardinals divergent, rather strong. Interdentum present, but not very broad. Beak-cavities not very deep. Nacre white, often suffused with salmon-pink.

| | L. | H. | D. | Pr.ct. |
|---|---|---|---|---|
| *Size:* 1. New Sheffield, Cat. No. 61.3343............ | 95 mm. | 71 mm. | 44 mm. | .46 |
| 2. Rosston, Cat. No. 61.2973................. | 65 " | 48 " | 28 " | .43 |

*Soft parts and Glochidia* (See Ortmann, 1911*b*, Pl. 89, fig. 2, and 1912, p. 241, fig. 4).

On May 24, 1911, in the Little Kanawha River, at Burnsville, Braxton Co., West Virginia, I found among numerous gravid females with normal (red) color

of the placentæ a single one, in which they were pure white. This has remained the only case of this kind. (I have seen over one hundred gravid females.)

*Breeding season:* Gravid females have been observed on the following dates. May 6, 1910; May 9, 1913; May 17, 1910; May 22, 1912; May 24, 1911; May 27, 1908; June 30, 1908; July 3, 1908; July 8, 1907; August 3, 1909; August 10, 1909. In the month of May only eggs were found, at the other dates eggs and glochidia, or only the latter. The species is typically tachytictic, breeding from May to August.

*Remarks:* This is a rather characteristic shell, but it has been frequently confused with other species, chiefly with *Pleurobema obliquum coccineum* (Conrad). Nevertheless the peculiar, subtrapezoidal shape, the pale brown or reddish epidermis, the flat sides, and distinct posterior ridge, always serve to distinguish it. It is, however, quite variable, and, as we shall see below, three varieties may be distinguished in Pennsylvania, and there are others outside of this state, which have often been regarded as distinct species. In spite of this it has been positively ascertained that these varieties actually intergrade in our region.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Ohio River, Neville Island, Allegheny Co.

Monongahela River, Elizabeth, Allegheny Co. (D. A. Atkinson & Graf); Charleroi (G. A. Ehrmann) and Millvale, Washington Co. (J. A. Shafer).

Raccoon Creek, New Sheffield, Beaver Co.

Chartiers Creek, Carnegie, Allegheny Co. (D. A. Atkinson & Graf).

North Fork Tenmile Creek, Amity, Washington Co.; South Fork Tenmile Creek, Waynesburg, Greene Co.

Dunkard Creek, Wiley and Mount Morris, Greene Co.

Allegheny River, Godfrey, Johnetta, and Kelly, Armstrong Co.

Crooked Creek, Rosston and Southbend, Armstrong Co.; Creekside, Indiana Co.

*Other localities represented in the Carnegie Museum:*

*Lake-drainage:*

Genesee River, Chili and Rochester, Monroe Co., New York (R. H. Santens).

Sandusky River, Fremont, Sandusky Co., and Upper Sandusky, Wyandot Co., Ohio (C. Goodrich).

Miami-Erie Canal, Lucas Co., Ohio (C. Goodrich).

Swan Creek, Toledo, Lucas Co., Ohio (C. Goodrich).

Maumee River, Defiance, Defiance Co., Ohio (C. Goodrich); Fort Wayne, Allen Co., Indiana (C. Goodrich).

St. Mary's River, Rockford, Mercer Co., Ohio (C. Goodrich).

Beaver Creek, Williams Co., Ohio (C. Goodrich).

St. Joseph River, Indiana (B. Walker).

Raisin River, Grape P. O., Monroe Co., and Adrian, Lenawee Co., Michigan (C. Goodrich).

Clinton River, Utica, Macomb Co., Michigan (B. Walker).

*Ohio-drainage:*

Tuscarawas River, Ohio (Holland collection).
Wolfe Creek, Washington Co., Ohio (W. F. Graham).
Chillicothe, Ross Co., Ohio (Hartman collection).
Ohio Canal, Columbus, Franklin Co., Ohio (Smith collection).
Scioto River, Kenton, Hardin Co., Ohio (C. Goodrich).
Wabash River, New Corydon, Jay Co., Geneva, Adams Co., and Bluffton, Wells Co., Indiana (C. Goodrich).
Little Kanawha River, Burnsville Braxton Co., West Virginia.
North Fork Hughes River, Cornwallis, Ritchie Co., West Virginia.
Pocatalico River, Raymond City, Putnam Co., West Virginia.
Coal River, Sproul, Kanawha Co., West Virginia.
Levisa Fork Big Sandy River, Prestonsburg, Floyd Co., Kentucky.
Licking River, Farmer, Rowan Co., Kentucky.

*Drainage of upper Mississippi and Red River of the North.*

Kishwaukee River, Rockford, Winnebago Co., Illinois (P. E. Nordgren).
Sheyenne River, Argusville, Cass Co., North Dakota (S. M. Edwards).

*Western and Southwestern Range.*

Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).
Wakarusa River, Lawrence, Douglas Co., Kansas (R. L. Moodie donor).
Wea Creek and Bull Creek, Miami Co., Kansas (C. Goodrich donor) (Osage drainage).
Neosho River, Burlington, Coffey Co., Kansas (R. L. Moodie donor).
Terre Noir Creek, Mount Zion, Clark Co., Arkansas (H. E. Wheeler).
Big Deciper Creek, Gum Springs, Clark Co., Arkansas (H. E. Wheeler).
Chikaskia River, Tonkawa, Kay Co., Oklahoma (F. B. Isely).
Illinois River, Talequah, Cherokee Co., Oklahoma (F. B. Isely).
Blue River, Durant, Bryan Co., Oklahoma (F. B. Isely).

*Note:* The specimens from Arkansas and Oklahoma are absolutely indistinguishable from the Pennsylvanian form in shape and anatomy, but have generally a more brilliant, shining, reddish epidermis.

*Distribution and Ecology in Pennsylvania* (See fig. 3): In our state *F. flava* is eminently characteristic of smaller streams, avoiding the larger rivers, although it has been found in the Allegheny, Monongahela, and Ohio. It is most abundant in the southwestern section of the state (Monongahela-drainage), and locally is rather plentiful, as for instance in Raccoon, Tenmile, and Dunkard Creeks. In the Allegheny River it is rather scarce, but is found in considerable numbers in Crooked Creek. Nevertheless elsewhere in the Allegheny-drainage it is absent, which is especially true of French Creek and the uppermost Allegheny, where there is a rich fauna still present, which has been well investigated. It is also absent in the whole Beaver-drainage.

It is hard to say what may have caused this peculiar condition. Yet attention should be called to the fact that the Beaver River and French Creek belong to the Glacial area, and that all creeks in Pennsylvania, in which this species is found, are entirely outside of this area. In the Kiskiminetas, Red Bank, and

Clarion Rivers the fauna is entirely destroyed, and the few survivals we have in the headwaters of the Kiskiminetas do not include this species.

*F. flava* prefers fine gravel and sand, and avoids rough bottom and rocks. Its favorite stations are on bars of fine, firmly packed gravel, just below riffles.

*General Distribution: Type locality*, Small tributaries of Kentucky, Salt River, and Green River (Rafinesque).

Outside of Pennsylvania this form has a wide range. It has been reported from western New York (see below) westward as far as Kansas and southeastern Nebraska. Northward it passes into Canada and the drainage of the Red River of the North (Winnipeg, compare also our specimens from North Dakota). In Michigan, it is all over the southern half of the lower peninsula (Walker's map, 1898, Pl. 1). It probably reached the lake-drainage by several ways, but not through Pennsylvania, since it is missing in the Beaver and upper Allegheny basins.

From the Ohio River southward its range becomes obscure. As I have discovered, it is present in the Little and Big Kanawha-drainages in West Virginia, and also in the Big Sandy and Licking Rivers in Kentucky. The type locality is in central Kentucky. Records from Tennessee are missing, except that given by Wilson & Clark (1914) Stones River, Tennessee, tributary to the Cumberland. The localities quoted from Mississippi, Alabama, and Texas are more than doubtful. But, as our material shows, forms representing the species are certainly found as far west as Arkansas and Oklahoma, and although certain authors might call, and have called, these by different names, I am unable to distinguish them from the northern form, except by their more shining epidermis. (See Wheeler, 1918, p. 123.)

It would be interesting to know whether outside of Pennsylvania the rule likewise holds good, that this form prefers smaller creeks. This is certainly the case, wherever I have collected it in West Virginia and Kentucky.[14] The localities in Arkansas, and partly also in Oklahoma, are small creeks, while in the larger rivers (Ouachita) *F. flava undata* and *trigona* are found. Call (1900, p. 506) says that *rubiginosus* (*flava*) is found in Indiana, in streams both large and small, while Wilson & Clark (1912*a*, pp. 42, 43) report *flava* from the headwaters of the Kankakee system in Indiana, while they cite *trigona* from the lower Kankakee and Iroquois Rivers in Illinois. In the uppermost Wabash and in the Maumee C. Goodrich collected only typical *flava*, and here undoubtedly is one of the places, where it

[14] However, in Elk River in West Virginia this is not perfectly clear. Here is found a form which may be called a dwarfed *F. flava trigona*. But this is in keeping with the general character of the Elk River fauna, which should be designated as a dwarfed big-river-fauna. It is not the place here to give details of these remarkable conditions.

crossed into the lake-drainage. There is no doubt that *flava* has often been confounded with *trigona* (or even *undata*), and that it actually intergrades through *trigona* into *undata*.

### Fusconaia flava trigona (Lea) (1831).

*Quadrula trigona* (Lea) Simpson, 1900, p. 787; *Quadrula undata* (Barnes) (Ohio-form) Walker, 1910*b*, p. 22; *Quadrula undata* (Barnes) Simpson, 1914, p. 880 (*pro parte*).

Plate II, fig. 1.

*Records from Pennsylvania:*

Stupakoff, 1894, p. 135 (Allegheny Co.).
Rhoads, 1899, p. 137 (Ohio River, Coraopolis, Allegheny Co.).[15]

*Characters of variety:* This is a *Fusconaia flava* which has a more swollen shell, chiefly anteriorly, with a diameter of fifty-five percent of the length or more. In consequence of this the sides of the shell are generally more concave, forming a gentle radial depression in front of the posterior ridge. In other respects there are hardly any differences from the normal form.

| | L. | H. | D. | Pr.ct. |
|---|---|---|---|---|
| *Size:* 1. Neville Island, Cat. No. 61.1837*b* | 67 mm. | 52 mm. | 38 mm. | .57 |
| 2. do. Cat. No. 61.1633*b* | 50 " | 41 " | 31.5 " | .63 |
| According to Lea's figure | 59 " | 49 " | 38 " | .64 |

The *soft parts* have never been observed in Pennsylvania. But specimens referable to this form have been found with the soft parts in Elk River, West Virginia, and gravid females were found there on July 8, 1911, with glochidia. The anatomy is absolutely identical with that of *F. flava*, as are also the *glochidia:* L. 0.15 mm., H. 0.16 mm. A form indistinguishable from this was collected by H. E. Wheeler in Saline River, Arkansas (July 13, 1911), and the anatomy and glochidia of this form were the same.

According to the above dates, the end of the *breeding season* of this form falls in July.

*Remarks:* In this case also I have been compelled to draw an artificial dividing line, at the diameter of fifty-five percent, between two forms, while in nature a gradual transition exists. This is justified by the same practical considerations as in the case of *Fusconaia subrotunda* and *kirtlandiana*. Walker specifically unites the present form with *undata* and he is undoubtedly right. Yet I think we should recognize *trigona* as a distinct *variety*, with less developed beaks; while *F. flava undata* has much elevated and often incurved beaks. The range of the two forms

[15] I have (1909*b*, p. 183 and 187) questioned the correctness of this record, since Rhoads' specimens are too young. But it should stand.

also seems to be somewhat different, *F. flava undata* (Barnes), belonging to the larger rivers of the central basin, being absent in Pennsylvania. In the middle West (Illinois) these two forms seem, however, to overlap, and in the Southwest also both seem to be present, and, according to what Walker says, intergrades are present. The real *F. flava undata* is, in consequence of the higher beaks, more subtrigonal (not subtrapezoidal) in outline, and in addition has the tendency in the epidermis to become greenish rather than brownish.

From the measurements given above we see that some of our specimens agree rather closely with Lea's figure of *U. trigonus*. Others reveal transitions in the direction of *F. flava*. Specimens from Charleroi have been determined by Simpson as intergrades between *trigona* and *rubiginosa* (= *flava*), and this is entirely correct. We have here (or rather had) in the Ohio below Pittsburgh, and in the Monongahela above, a region, where *flava* gradually passes into *trigona*. Further upstream, chiefly in the Monongahela system, only more or less typical *F. flava* are found. The only way to bring order out of the chaos is to draw an artificial line, as I have done.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Ohio River, Neville Island, Allegheny Co.

Monongahela River, Westmoreland Co. (G. A. Ehrmann); and Charleroi, Washington Co. (G. A. Ehrmann).

*Other localities represented in the Carnegie Museum:*

Elk River, Sutton and Gassaway, Braxton Co., and Shelton, Clay Co., West Virginia.[16]

West Fork White River, Riverside, Greene Co., Indiana (J. D. Haseman).

Wabash River, New Harmony, Posey Co., Indiana (A. A. Hinkley).

(A form indistinguishable from this has been received from various localities in the Southwest; but they cannot be distinguished from *U. chuni* Lea.)

Marais des Cygnes River, Rich Hill, Bates Co., Missouri (W. I. Utterback).

Cache River, Nemo, Craighead Co., and Sedgwick, Lawrence Co., Arkansas (H. E. Wheeler).[17]

White River, Cotter, Baxter Co., Arkansas (A. A. Hinkley).

Saline River, Benton, Saline Co., Arkansas (H. E. Wheeler).[18]

Kiamichi River, Tuskahoma, Pushmataha Co., Oklahoma (F. B. Isely).

Sabine River, De Soto Parish, Louisiana (L. S. Frierson).

*Distribution and Ecology in Pennsylvania* (See fig. 3): *F. flava trigona* is found in Pennsylvania only in the Ohio and lower Monongahela Rivers, and reaches here

[16] Smaller than the Pennsylvanian form, but agreeing in all other respects. A few specimens from Gassaway would fall under typical *flava*, but the diameter remains above fifty percent.

[17] In part cotypes of *F. selecta* Wheeler (Nautilus, XXVIII, 1914, p. 76, Pl. 4). I cannot separate them from this form.

[18] In some of these, the diameter falls below fifty-five percent, but remains above fifty percent.

the uppermost limit of its distribution in the Ohio system. It is remarkable that I have not found this form or any representative of it in the Ohio in Beaver County. Its absence in the lower Allegheny may be accounted for by the general destruction of the molluscan fauna in these waters. Moreover *F. flava trigona* probably is extinct in the state at the present time. The specimens collected by myself at Neville Island were all dead, and there are no more shells at this locality, nor at Rhoads' locality, Coraopolis. Ehrmann's collections in the Monongahela were made before 1898, and most of his shells were found dead.

*General Distribution. Type locality:* Ohio River, Cincinnati and Louisville (Lea).

The distribution of *F. flava trigona* is very unsatisfactorily known. Walker reports it from the Ohio, and it extends westward to the Mississippi at Davenport, Iowa, and to the Wisconsin River, Sauk Co., Wisconsin (Walker).

The Carnegie Museum possesses a number of specimens from the Kishwaukee River, Rockford, Winnebago Co., Illinois (P. E. Nordgren), which in general correspond with *F. flava;* but one among them, which is considerably swollen, might very well be considered to belong to the variety *trigona*. These shells are rather large, with blackish epidermis. The other localities mentioned above, are rather isolated (in West Virginia, Indiana, Arkansas, Oklahoma, Louisiana), but they tend to show that under certain conditions, the form *flava undata* passes, in localities remote from each other, into a form with less elevated beaks, which answers to the description of *U. trigonus* of Lea. What these conditions are, remains to be seen. Possibly *trigona* is the form of medium-sized rivers with strong currents.

It is remarkable that I did not see a trace of this form on my collecting trips down the Ohio between Pittsburgh and Cincinnati. The shell should be expected in this region, but careful examination of the shell-heaps of the clam-diggers and my own collecting did not bring to light a single specimen. Probably this form selects particular stations in the river, but of what character these are, is as yet unknown. At Neville Island in Pennsylvania, I found the dead shells in and above riffles in a small branch of the Ohio, immediately below a rather long, quiet pool.

### Fusconaia flava parvula Grier (1918).

*Unio rubiginosus* Norris, 1902, p. 119 (Winona Lake); *Quadrula rubiginosa* Ortmann, 1909*b*, p. 203 (Lake Erie); *Quadrula undata* (*pars*) Walker, 1910*b*; *Quadrula undata* (*pars*) Simpson, 1914, p. 880; *Fusconaia flava parvula* Grier, 1918, p. 11.

Plate II, fig. 2.

Previously reported as a *distinct* form, only by Grier (1918) but referred to by Ortmann, 1909*b*, p. 203, as *Quadrula rubiginosa*.

*Characters of variety:* Much smaller than *F. flava* and *F. flava trigona*, generally less than half their size and bulk. The shape of this form is much like that of the var. *trigona* (subtrapezoidal), although sometimes there are found more triangular specimens, which incline towards the western *F. flava undata*. With regard to the swelling of the valves, there is great variety, some specimens being almost as flat as the normal *F. flava*, but on the average, the swelling, and also the development of the beaks, is more like that of *F. flava trigona*, with the diameter generally over fifty percent of the length. Color of epidermis, when young, rather light, yellowish brown (in Lake Erie), or greenish brown (in Winona Lake), with very distinct and regular, dark growth-rests, and fine, indistinct greenish or brownish rays. Old shells become darker, chestnut-brown or greenish black (the latter is the case in Winona Lake). Old specimens are sometimes unusually drawn out at the lower posterior end, and thus become oblique.

| | L. | H. | D. | Pr.ct. |
|---|---|---|---|---|
| *Size:* 1. Erie, Cat. No. 61.3886 | 59 mm. | 49 mm. | 31 mm. | .53 |
| 2. do. Cat. No. 61.4371 | 57 " | 49 " | 33 " | .58 |
| 3. do. Cat. No. 61.4513 (Type set) | 52 " | 41 " | 27 " | .52 |
| 4. do. Cat. No. 61.4370 | 41 " | 35 " | 23 " | .56 |

The first two shells are very old, the largest at hand, and they are much drawn out posteriorly; the third and fourth are good average specimens.

*Soft parts:* They have been alluded to by Ortmann (1912, p. 241), under *F. undata*. A gravid female with young glochidia was subsequently secured from Cedar Point, Ohio, and, as far as could be made out, the *glochidia* agree in shape and size with those of *F. flava*.

*Breeding season:* Gravid females were found in Presque Isle Bay on July 8, 9, and 12, 1910. They did not have glochidia. The specimen from Cedar Point with young glochidia was collected July 24, 1911.

*Remarks:* This is the Lake Erie form of *F. flava*, and a similar form is found in Winona Lake in Indiana. The latter agrees in size, and also in general shape, although the tendency toward the triangular shape of *F. flava undata* is more pronounced. It is, however, more greenish brown in color, while specimens from Lake Erie are more yellowish or rusty brown. One specimen from Winona Lake is as flat as *F. flava*.

The variety from Lake Erie is quite distinct, characterized chiefly by its small, dwarfed size, and by having more distinct and regular growth-lines, a

feature noticeable in almost all species found in Lake Erie. In other respects this variety is rather indifferent; it inclines most toward the var. *trigona*, but there is a tendency in some individuals to become more triangular (with higher beaks), like *F. flava undata*. With regard to obesity, it is very variable, and some specimens are as flat as *F. flava;* in fact, young specimens are very often found, which are indistinguishable from young *F. flava*.

*Localities represented in the Carnegie Museum:*

Lake Erie, Presque Isle Bay, Erie, Erie Co., Pa.; and also in Horseshoe Pond on Presque Isle.

Lake Erie, Crystal Beach, Welland Co., Ontario, Canada (F. Behrle); Port Rowan, Norfolk Co., Ontario, Canada (C. Goodrich); Sandusky Bay, Cedar Point, Erie Co., Ohio (O. E. Jennings); La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).

Winona Lake, Kosciusko Co., Indiana (E. B. Williamson).[19]

*Distribution and Ecology* (See fig. 3): *Type locality,* Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania. *Type set:* Carnegie Museum, Cat. No. 61.4513.

Aside from the range indicated by the above localities, no details are known. Walker (1910*b*, p. 22) mentions that *Quadrula undata* has invaded the St. Lawrence system, and that it is found in the lake-drainage in Wisconsin, Illinois, and southern Michigan, and that it goes eastwards as far as Buffalo, New York, and Port Dover, Ontario (in Lake Erie); and in 1913, Walker cites both *rubiginosa* and *undata* from Lake Erie, but the form from Lake Erie has not been discussed in detail. We do not know whether the var. *parvula* is restricted to the lake, or also found elsewhere. Marshall (1895, pp. 89 and 93) calls the Lake Erie form from New York both *rubiginosa* and *trigona*.

As far as my material goes (I have seen over fifty specimens from Lake Erie) *F. flava parvula* is a well-marked local form, easily distinguished from the other phases of the species. However, it would not be astonishing if it should pass elsewhere into the other forms, in fact, the shells from Winona Lake represent to a degree transitions both toward *F. flava* and *F. flava undata*.

Possibly the dwarf form of *Quadrula rubiginosa* from Tippecanoe and Kuntz Lakes in northern Indiana, mentioned by Wilson & Clark (1912*a*, p. 43), difficult to distinguish from *trigona*, belongs here.

The mutual connection of the three forms described above has hitherto been misunderstood, and some authors have been quite emphatic in the assertion that *rubiginosa* (= *flava*) should not be united specifically with *undata* or *trigona* (Call, 1895; Walker, 1910*b*). But upon the basis of my own studies of the conditions in western Pennsylvania, I am as emphatic in maintaining that *flava* is only the

[19] These were received as "*coccinea*," but undoubtedly correspond to "*rubiginosa*" of Norris' list (1902) from Eagle (= Winona) Lake.

creek-form of the river-form *flava trigona*. As I have pointed out under *flava trigona*, the latter has (or had) in the Ohio and Monongahela near Pittsburgh a distinct tendency to become more flattened. There are all intergrades in this respect before me, and it is absolutely impossible to draw a natural line between the swollen *trigona*-form, and the flat *flava*-form. Farther up in the Monongahela and Allegheny, and in their tributaries, and also in the smaller tributaries of the Ohio proper, the pure and typical *F. flava* is exclusively found.

Conditions like these force us to unite these forms specifically. But nevertheless *trigona* is to be regarded as a distinct variety, constituting a geographical, or rather ecological, race of *F. flava*, which has its definite habitat in larger streams. There are indications that similar conditions prevail outside of Pennsylvania.

Attention should be called to the singular parallelism of these forms with those of the *Fusconaia subrotunda*-group. In the latter, we have seen that there is a greatly swollen form, with highly elevated and incurved beaks (*F. ebena*) living in the largest, deepest rivers, with muddy bottoms, and therefore in those regions, which are nearest to the center of the interior basin. In the great rivers with sandy and gravelly bottoms and somewhat stronger current, that is to say in the upper Ohio, this is replaced by a form, which, although more or less swollen, has less elevated beaks (*F. subrotunda*). This in turn in the smaller streams gives way to a flat form (*F. kirtlandiana*). The same is true apparently in the *F. flava*-group. We observe a very swollen form with high beaks having the Mississippi as the center of its range (*F. undata*); a swollen form with less elevated beaks in the upper Ohio (*F. trigona*); and a flat form in the smaller creeks (*F. flava*). To these is added, in this case, a dwarfed lake-form in Lake Erie (*F. parvula*).

The boundaries of these corresponding forms of the two series do not coincide, inasmuch a *F. subrotunda* goes farther up in the rivers than does *F. flava trigona*.

It is well to keep this peculiar phenomenon in mind, for later on we shall become acquainted with other instances of the same kind.

Further, attention should be called to the peculiar fact that, while the form *flava* is entirely missing in northwestern Pennsylvania, and is represented in Lake Erie by the form *parvula*, it turns up again in western New York. The Carnegie Museum has specimens from the environs of Rochester, New York, and it had been previously reported from the region of Buffalo and the Erie Canal, from the Genesee River and the Mohawk, crossing over to the Atlantic slope (See Call, 1878, and 1885; Dewey, 1856; Marshall, 1895; Baker, 1898*b*). According to Call, it has migrated along this route in recent times. Since this range has no connection with the rest of the range of *F. flava*, we must assume that it came

into this region from Lake Erie near Buffalo, and that it is the form *parvula* which originally entered the tributaries and canal, but which under the changed environment, again assumed the shape and the characters of the form of the creeks, called *flava*. This is a very interesting phenomenon, and appears to indicate the very important influence of environment upon the shape of the external characters of the shell. If this were the only instance of the kind, we might regard it with suspicion, but we shall become acquainted with other facts of a similar nature, and in order not to loose sight of this instance, it is emphasized here.

Finally attention should be directed to the great tendency to develop local forms within the *flava*-group. Although we have distinguished only four main forms (*undata, trigona, flava, parvula*) some of these include several local types. For instance, the *flava* of the Allegheny River and Crooked Creek in Pennsylvania is distinguished by small size, while in the creeks of southwestern Pennsylvania a much larger form prevails. In the Little Kanawha River in West Virginia is a very peculiar race of *flava*, distinguished by a shape, which is considerably drawn out at the lower posterior end. A peculiar small race of *trigona* is found in Elk River, West Virginia, and the forms from Arkansas also have certain characteristics of their own. These conditions are very interesting, but can be studied only with the help of larger series from the different localities.

## Genus Amblema Rafinesque (1820).

*Crenodonta* Ortmann, 1912, p. 245; *Crenodonta* (Schlueter) (section of *Quadrula*) Simpson, 1914, p. 813; *Amblema* Frierson, 1914*a*, p. 7; *Amblema* Utterback, 1916, p. 31.

Type *Amblema costata* Rafinesque.

Only one species, *A. plicata*, is found in Pennsylvania, within which, however, two well-marked races may be distinguished.

Key to the forms of A. plicata.

$a_1$. Shell smaller, generally more swollen, less elevated posteriorly. Sculpture less developed, chiefly so upon the posterior slope.......... *A. plicata.*

$a_2$. Shell larger, generally more compressed, and more elevated posteriorly. Sculpture better developed, chiefly so upon the posterior slope.......... *A. plicata costata.*

### Amblema plicata (Say) (1817).[20]

*Quadrula plicata hippopæa* (Lea) Simpson, 1914, p. 816; *Amblema plicata* (Say) Utterback, 1916, p. 33.

[20] Not 1816, as given by Simpson. (See Binney, Bibliography, 2, Smithsonian Miscell. Coll., 9, 1869, p. 277.)

Plate II, figs. 4, 5, 6.

*Records from Pennsylvania:*

Reported previously from Lake Erie, but not from the Pennsylvanian shores, except by Ortmann (1909*b*, p. 203) as *undulata hippopæa.*

*Characters of the Shell:* Shell of medium size, rather heavy. Outline suboval to subtrapezoidal, generally slightly longer than high, somewhat oblique, rounded before, subtruncate behind. Beaks moderately prominent. Beak-sculpture consisting of three to five concentric ridges, slightly angular and nodulous behind; only one to three are distinct, the others indistinct, often indicated only by the nodules. The beak-sculpture is not continued upon the disk. Shell moderately swollen, with indistinct, rounded posterior ridge. Surface sculptured by transverse, oblique folds or undulations, which run parallel to each other in the direction of the lower posterior end. These folds are absent in very young shells, and begin in older individuals at a certain distance from the beaks, and at, or a little in front of, the middle of the disk, leaving the anterior part of the shell free. These folds are very variable, sometimes hardly indicated, in other cases they are rather strong. In large shells, there are as many as four or five of them. Posterior slope comparatively narrow, since the upper posterior margin is only little, or not at all elevated, so that the posterior wing is only slightly developed. In younger shells, however, it is generally well-developed. The posterior slope is often entirely smooth, but sometimes there are indications of radiating folds or ribs, smaller than those upon the middle of the disk, and occasionally they may become rather distinct and strong. In the latter case they have no distinct relation to the large folds, but seem to diverge from the uppermost of the latter at an angle. Epidermis in young specimens yellowish or greenish brown, rather light, without rays. Growth-lines dark. In old shells the epidermis becomes darker, reddish or chestnut-brown to blackish, and the growth-rests, which are rather regular, become less marked in color.

Hinge-teeth strong, ragged. Pseudocardinals divergent. Interdentum moderately developed. Lateral teeth strong and rather long. Beak-cavity of medium depth. Dorsal muscle-scars on the hinge-plate. Nacre white, posteriorly often very beautifully iridescent with purplish and pinkish reflections. No difference whatever between the male and female shell.

| | | L. | H. | D. | Pr.ct. |
|---|---|---|---|---|---|
| *Size:* 1. Erie, Cat. No. 61.4520 | (largest, ♀) | 98 mm. | 71 mm. | 40 mm. | .41 |
| 2. do. Cat. No. 61.4520 | (♂) | 68 " | 54 " | 30 " | .44 |
| 3. do. Cat. No. 61.4516 | (♂) | 46 " | 36 " | 20 " | .43 |

*Soft parts* (See Ortmann, 1912, p. 246). *Glochidia* unknown.

*Breeding season:* Of this form, I have found only two gravid females, with eggs, on July 8, 1910. The eggs were white.

*Remarks:* The nomenclature of this species and its forms has been erroneous hitherto, and the original *U. plicatus* of Say has been entirely misunderstood by practically all authors, except Utterback (1916). Indeed, from Say's description alone it is impossible to decide what form of the *plicata*-group he had before him, but the locality he gives, Lake Erie, settles the case. There is no other form of the *plicata*-group in the lake,[21] except this, and consequently the common form from Lake Erie should bear this name, and not that of *hippopœa* given by Lea.

*A. plicata* of Lake Erie is not the normal type of the species, but is a dwarfed form of a species of the Ohio-drainage (*costata*). Thus nomenclature reverses the natural conditions, making out of a local race the typical form of the species, but this cannot be helped. The differences of *A. plicata* from the Ohio-form *costata* are very slight, in fact, the only reliable distinction is the size, but there are a few others, which may be more or less depended upon. The typical *plicata* is generally more oval, and the posterior part (wing) is not so elevated. Furthermore the growth-lines are more regular and closer together, the shell is slightly more swollen on the average, and the color lighter. But in young specimens all these characters are more or less obscured, and it is practically impossible to distinguish these two forms in the juvenile stage. I have young *costata* which may be matched with young *plicata*, without showing the slightest difference.

*Localities represented in the Carnegie Museum:*

Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania.
Lake Erie, Cedar Point and Sandusky Bay, Erie Co., Ohio (O. E. Jennings and Chas. Brookover).
Lake Erie, La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).

*Distribution and Ecology* (See fig. 4). *Type locality:* Lake Erie (Say).

This species is known in Pennsylvania only from Lake Erie. In Presque Isle Bay it is rather abundant, and at certain places sometimes great numbers of young shells are found in one to two feet of water. The larger specimens are generally found at a depth of three to four feet, and with the clam-dredge I obtained some at five feet, and others were brought up by the "sand-sucker" from a depth of ten to fifteen feet. They are found generally in fine sand and gravel, but I also found a few on the southern shore of the bay (mainland), where the bottom consists of coarse shingle.

[21] I have received, from L. S. Frierson, a true *A. plicata costata* from Maumee Bay at the mouth of the Ottawa River, near Toledo, Lucas Co., Ohio. This however, is a dead shell, and may have been washed into the lake from the Ottawa or Maumee Rivers, in both of which *A. plicata costata* is present.

Outside of Pennsylvania this species has been recorded only from those states which border on Lake Erie. It is known from Buffalo, New York (Marshall, 1895, p. 50), but said to be identical with *U. undulatus* (= *A. costata*). It is given

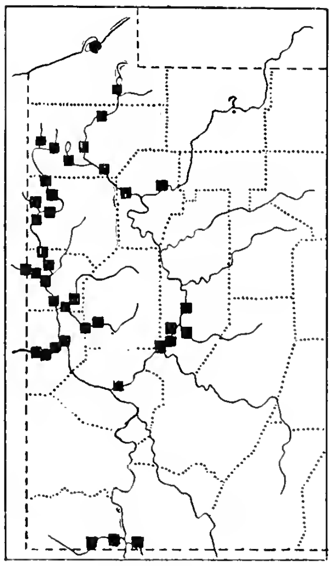

Fig. 4.
● *Amblema plicata.*
■ *Amblema plicata costata.*

from the Ohio shores of the lake by Sterki (1907*a*), and from the shores in southeastern Michigan (Walker, 1898), and from Lake Erie in general (Walker, 1913).

The record from Lake Winnipeg, Canada (Hanham, 1899) should be questioned for the present.[22]

Amblema plicata costata (Rafinesque) (1820).

*Quadrula undulata* (Barnes) Simpson, 1914, p. 819;[23] *Quadrula costata* (Rafinesque) Vanatta, 1915, p. 556; *Amblema plicata costata* (Rafinesque) Utterback, 1916, p. 33.

Plate II, fig. 7; Plate III, figs. 1, 2, 3.

*Records from Pennsylvania:*

Clapp, 1895 (Allegheny Co.).
Marshall, 1895 (Allegheny River, Warren Co.).[24]
Rhoads, 1899 (Ohio River, Beaver Co., and Beaver River, Wampum, Lawrence Co.) (as *plicatus*).
Ortmann, 1909*b*, p. 198.

[22] Simpson (1900, p. 769, footnote 3) mentions a peculiar form of "*undulata*" from Lake Winnipeg. Possibly this is the same as that referred to by Hanham, and might be a form parallel to *plicata*.

[23] Simpson makes a singular mistake in quoting, among the synonyms, *Unio undulatus* Sowerby, 1868, Pl. 76, fig. 399, which probably is *Alasmidonta undulata* (Say).

[24] I did not find this form so far up in the Allegheny, but only as high up as Venango Co., where it is very rare. But it may have extended farther up in the past.

*Characters of variety:* This form differs from *plicata* of Lake Erie by being considerably larger, attaining a huge size; in fact it is one of our largest and heaviest shells. The shell is generally rather flat, with the diameter less than forty percent of the length, and the posterior wing is well-developed, so that the upper margin appears elevated posteriorly. The beaks are very slightly prominent. The surface sculpture is similar to that of *plicata*. In large specimens there are upon the sides four or five transverse bars, but they are, as a rule, more distinct and broader than in *A. plicata*. The radiating ribs upon the posterior slope and the wing are more frequently and more distinctly developed. Color of epidermis generally darker, although young shells are often as light as *plicata*. The growth-lines are less regular, and old shells become uniformly black. Nacre white, often beautifully iridescent posteriorly. No difference between the male and the female in the shell.

| | L. | H. | D. | Pr.ct. |
|---|---|---|---|---|
| *Size:* 1. Jamestown, Cat. No. 61.3831............ | 161 mm. | 123 mm. | 68 mm. | .42 |
| 2. Mahoningtown, Cat. No. 61.3830........ | 99 " | 78 " | 38 " | .38 |

No. 1 is the largest specimen on hand.

*Soft parts* and *Glochidia* (See Ortmann, 1912, p. 246).

*Breeding season:* Typically tachytictic, breeding from May to July. I found gravid females on the following dates: May 13, 1911; May 17, 1910; May 23, 1911; May 23, 1912; May 23, 1914; May 24, 1911; June 19, 1909; July 3, 1908; July 8, 1909; July 10, 1909; July 10, 1911. Glochidia were seen only in July, and a discharging specimen was observed on July 10, 1911. Wilson & Clark (1912*a*) report gravid specimens as late as July 28.

*Remarks: Amblema plicata costata* undoubtedly is the parent form, from which *A. plicata* is derived as a depauperate form in Lake Erie. The former is rather variable in some of its characters, but it is always much larger, generally more compressed, and the posterior wing is more elevated. The sculpture varies a good deal. I have specimens in which the shell is practically smooth, without any folds (Compare the figures of Baker, 1898*a*, Pl. 12, fig. 1; Smith, 1899, Pl. 82, and our figs. 2 and 3 on plate III). Sometimes the folds are peculiarly developed, showing a tendency to be divided into nodes. I have even a specimen in which these nodes form irregular vertical ribs, running toward the lower margin of the shell, so that, together with the ribs of the posterior slope, a system of low bars is indicated, which diverge from the posterior ridge of the shell in the direction of the lower and posterior margins.

The specimens from Pennsylvania are all to be regarded as true *costata*, and I have not seen any forms which incline toward the western and southwestern

representatives; nevertheless there is a tendency in this form to become more swollen in the larger rivers (See Pl. III, figs. 2, 3).

*Localities in Pennsylvania represented in the Carnegie Museum:*

Ohio River, Shippingport, Cooks Ferry, and Industry, Beaver Co.
Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Mahoning River, Mahoningtown, Coverts, Edinburg, and Hillsville, Lawrence Co.
Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Sharpsville, Clarksville, Shenango, and Jamestown, Marcer Co.; Linesville, Crawford Co.
Connoquenessing Creek, Ellwood City, Lawrence Co. (G. H. Clapp, H. H. Smith, & G. L. Simpson, Jr.); Zelienople, Harmony, Butler Co.
Slippery-rock Creek, Wurtemberg, Lawrence Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Padan Creek, Linesville, Crawford Co. (O. E. Jennings).
Allegheny River, Aladdin, Godfrey, Johnetta, Kelly, and Mosgrove, Armstrong Co.; Walnut Bend, Venango Co.
Crooked Creek, Rosston, Armstrong Co.
French Creek, Utica, Venango Co.; Cochranton, Meadville, and Cambridge Springs, Crawford Co.
Conneaut Outlet, Conneautlake, Crawford Co.
Leboeuf Creek, Waterford, Erie Co.
Dunkard Creek, Dunkard, Mount Morris, Greene Co.
Cheat River, Cheat Haven, Fayette Co.

*Locality in Pennsylvania represented in the Philadelphia Academy of Natural Sciences:*

Ohio River, Beaver, Beaver Co. (S. N. Rhoads).

*Other localities represented in the Carnegie Museum:*

*Lake-drainage:*

Tonawanda Creek, Erie Co., New York (Smith collection).
Sandusky River, Upper Sandusky, Wyandot Co., Ohio (C. Goodrich).
Maumee River, Roche de Boeuf Rapids and Otsego Rapids, Wood Co., Ohio (C. Goodrich).
Swan Creek, Toledo, Lucas Co., Ohio (C. Goodrich).
Silver and Beaver Creeks, Williams Co., Ohio (C. Goodrich).
St. Mary's River, Rockford, Mercer Co., Ohio (C. Goodrich).
Ottawa River, Lucas Co., Ohio (C. Goodrich)..
Lake Erie, Maumee Bay, at mouth of Ottawa River, Lucas Co., Ohio (L. S. Frierson donor).[25]
Raisin River, Grape P.O., Monroe Co., and Adrian, Lenawee Co., Michigan (C. Goodrich).
Rouge River, Wayne Co., Michigan (C. Goodrich).
Gratiot Co., Michigan (C. Goodrich) (Saginaw drainage).

*Ohio-drainage:*

Ohio River, Toronto, Jefferson Co., Ohio; St. Mary's, Pleasants Co., and Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio.
Conotton Creek, New Hagerstown, Carroll Co., Ohio.
Tuscarawas River, Ohio (Holland collection).

[25] A dead shell, probably washed into the lake from the river.

Wolfe Creek, Washington Co., Ohio (W. J. Graham).
Ohio Canal, Columbus, Franklin Co., Ohio (Smith collection).
Scioto River, Kenton, Hardin Co., Ohio (C. Goodrich).
Big Beaver Creek, Mercer Co., Ohio (C. Goodrich).
Wabash River, New Corydon, Jay Co., Geneva, Adams Co., and Bluffton, Wells Co., Indiana (C. Goodrich).
West Fork River, Lynch Mines, Harrison Co.; Milford, Harrison Co. (W. J. Graham); Lightburn and Weston, Lewis Co., West Virginia.
Little Kanawha River, Grantsville, Calhoun Co. (W. J. Graham) and Burnsville, Braxton Co., West Virginia.
North Fork Hughes River, Harrisville (W. J. Graham), and Cornwallis, Ritchie Co., West Virginia.
Elk River, Shelton, Clay Co., and Gassaway and Sutton, Braxton Co., West Virginia.[26]
Levisa Fork Big Sandy River, Prestonsburg, Floyd Co., Kentucky.
Licking River, Farmer, Rowan Co., Kentucky.

*Tennessee-drainage:*

French Broad River and Boyd Creek, at Boyd Creek, Sevier Co., Tennessee.
Nolichucky River, Chunns Shoals, Hamblen Co., Tennessee.
Holston River, Hodges, Jefferson Co.; Turley Mill and Noeton, Grainger Co.; Austin Mill, Hawkins Co., Tennessee.
South Fork Holston River, Pactolus, Sullivan Co., Tennessee.
North Fork Holston River, Rotherwood, Hawkins Co., Tennessee; Hilton, Scott Co., Virginia.
Clinch River, Solway, Knox Co.; Clinton and Offutt, Anderson Co.; Black Fox Ford, Union Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Speers Ferry and Clinchport, Scott Co., Virginia; St. Paul, Wise Co., Virginia; Fink and Cleveland, Russell Co., Virginia.
Emory River, Harriman, Roane Co., Tennessee.
Powell River, Combs, Claiborne Co., Tennessee.

*From upper Mississippi northwards and westwards:*

Little Muddy Creek, DuBois, Washington Co., Illinois (A. A. Hinkley).
Sheyenne River, Argusville, Cass Co., North Dakota (S. M. Edwards) (drainage of Red River of the North).
Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).
James River, Galena, Stone Co., Missouri (A. A. Hinkley).
Terre Noir Creek, Mount Zion, Clark Co., Arkansas (H. E. Wheeler).

All the above specimens are to be considered as typical *A. plicata costata*. Other sets from Indiana, Illinois, northern Alabama (Tennessee-drainage), Kansas, Arkansas, and Oklahoma, show peculiar features, leading to the western and southern representatives of this form. I cannot go into detail here, yet it should be mentioned that I have from the Alabama drainage one set, which cannot be distinguished from *costata*. It is from Valley Creek, Toadvine, Jefferson Co., Alabama (H. H. Smith).

*Distribution and Ecology in Pennsylvania* (See fig. 4): This form is not rare in our state. It is found in the larger streams as well as in their tributaries, and in general is most abundant in some of the latter. In the Ohio below Pittsburgh it is not very plentiful; in the Monongahela proper it has not been found, and it is decidedly rare in the Allegheny. But it turns up again in some of the tributaries

[26] In the Kanawha drainage, I have seen a dead shell in Coal River, Sproul, Kanawha Co., W. Va.

of the Monongahela, and is abundant in its headwaters in West Virginia. In the Beaver-drainage it is nearly everywhere, being absent only in the smaller creeks. The same is true of French Creek.

It is generally found in the more or less coarse gravel of our streams, often in the Allegheny and Ohio among very heavy gravel and in strong currents, but it is by no means averse to fine gravel and sand (chiefly so when young). It avoids mud, as most of our Naiades do. The shell attains considerable size, and there is no relation between the size of the stream and that of the shell, very large individuals having been often found in small creeks.

*General Distribution: Type locality,* Ohio River (Rafinesque); according to Vanatta small creeks in Kentucky.

The range outside of Pennsylvania is very extended, and comprises practically the whole of the Ohio-drainage, including the Tennessee-Cumberland system, and westward, the Mississippi- and Missouri-drainages to Minnesota, Iowa, Nebaska, Kansas, and Oklahoma. Northwards it crosses into the drainage of the Great Lakes at several points, and has been reported as occurring as far northeast as Ottawa, Canada (Simpson, 1893, p. 592). It is found in western New York in Erie, Niagara, Monroe, and Onondaga Cos. (Marshall, 1895) in tributaries of the St. Lawrence system and along the route of the Erie canal. This group of localities, confirmed also by our specimens from Tonowanda Creek, is important (see below). It is not found in Lake Erie proper, being there replaced by *A. plicata.*

In Ohio it is present in both drainages (Sterki, 1907*a*), and has been repeatedly reported from streams running to Lake Erie; from the Cayuga, Rock, and Sandusky Rivers (Dall & Simpson, 1895), and also from the Maumee River (Carnegie Museum). This establishes one route of migration from the Ohio to the lake. It is furthermore found in southern Michigan (Walker, 1898). It also crosses over in the north into the Red River of the North and the Lake Winnipeg-drainages.

Towards the south and southwest, the boundaries of the range of the true *A. plicata costata* are poorly known. It certainly exists in tributaries of the Cumberland in Tennessee (Wilson & Clark, 1914), and in the headwaters of the Tennessee in eastern Tennessee and Virginia (Carnegie Museum). But farther in this direction it is replaced by the southern form (*perplicata*). In Arkansas and Oklahoma forms intergrading with the latter are found.

From the middle Ohio (region of Cincinnati) downward, and in the Mississippi River, its place is largely taken by the closely allied *Amblema peruviana* (Lamarck),[27]

[27] This is the *Quadrula plicata* of Simpson (1914, p. 814).

but particulars about the distribution of this form are scarce. As far as can be judged, *A. peruviana* seems to prefer the largest rivers, and probably muddy bottoms. In the Ohio from the Pennsylvania state line down to Portsmouth, Ohio, I have never seen a true *peruviana*.

In the distribution of the forms of the *A. plicata*-group two facts should be especially emphasized.

1. We have here a group of at least three forms: a dwarfed form from Lake Erie (*A. plicata*); a flat form found in the smaller rivers and headwaters (*A. plicata costata*); and a swollen form with high beaks in the largest rivers (*A. peruviana*). Only the first two are found in Pennsylvania, but the third turns up in the Ohio in the neighborhood of Cincinnati. These conditions correspond in a degree to what we have observed in two cases in the genus *Fusconaia* (See above, pp. 14 and 24).

2. In western New York, we have the typical form from small rivers, (*costata*) tributaries of the St. Lawrence system, apparently entirely isolated from the rest of the range, for this form is positively absent in the uppermost Allegheny-drainage. The form found in Lake Erie is not this, but *A. plicata*. Thus it seems that western New York has been colonized from the lake, the lake-form (*plicata*) again assuming the river form (*costata*). This case should be compared with what we have learned about *Fusconaia flava* (See p. 25).

### Genus Quadrula Rafinesque (1820).

Ortmann, 1912, p. 250; Simpson, 1914, p. 811.

Type *Obliquaria metanevra* Rafinesque.

Five well-defined species and one variety are found in Pennsylvania.

#### Key to the Species and Varieties of Quadrula.

$a_1$. Shell more or less regularly rounded, with tubercles, which are rather small and irregularly scattered, and have no connection with the weakly developed, concentric beak-sculpture. Epidermis yellow to brown, rayed, when young, rays green, often very broad and broken up into large spots.

- $b_1$. Shell rounded, high, not transverse. Posterior wing not developed. . . . . . . . . . . . . . *Q. pustulosa.*
- $b_2$. Shell more transverse. Posterior wing better developed. . . . . . . . . . *Q. pustulosa schoolcraftensis.*

$a_2$. Shell not rounded, but trapezoidal, triangular, or elongated. Sculpture consisting of tubercles, knobs, or ribs, of a more or less definite arrangement, more or less related to the beak-sculpture; the latter double looped or of the zig-zag type. Epidermis rayed in various patterns or spotted.

- $b_1$. Shell subtrapezoidal, with a narrow and blunt posterior ridge. In front of the latter a broad and shallow groove. Tubercles of posterior ridge not very large. Epidermis with irregular rays, rays often spread out, but not spotted.
  - $c_1$. Shell about as long as high. Groove of disk distinct, generally without nodules. *Q. quadrula.*

$c_2$. Shell much longer than high. Groove of disk shallow, and covered with the same nodules as the anterior part of the shell. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Q. verrucosa.*

$b_2$. Shell subtrapezoidal, with a broad and distinct posterior ridge. In front of this ridge, and behind, a slight depression, but no distinct radial groove. Tubercles of this ridge generally large. Rays of epidermis generally broken up into characteristic spots.

$c_1$. Shell subtrapezoidal or subrhomboidal, about as high as long. Sculpture of disk generally well-developed. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Q. metanevra.*

$c_2$. Shell subrectangular, much longer than high. Sculpture of disk often poorly developed. *Q. cylindrica.*

## Quadrula pustulosa (Lea) (1831).

*Quadrula pustulosa* (Lea) Simpson, 1914, p. 848.

Plate III, figs. 4, 5.

*Records from Pennsylvania:*

Harn, 1891 (Western Pennsylvania).

Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver River, Wampum, Lawrence Co.).

Ortmann, 1909*b*, p. 199.

*Characters of shell:* Shell of not more than medium size, but rather heavy. Outline subcircular, or obovate, about as high as long, not oblique, but rather upright. Beaks moderately prominent. Beak-sculpture consisting of two to three indistinct, concentric ridges, slightly angled and nodulous behind, not continued upon the disk. Shell from rather swollen to rather flat, evenly convex, without, or with very indistinct, posterior ridge. Basal margin evenly rounded. Surface sculptured by very irregular and variable nodules or pustules, absent towards the beaks. Sometimes the surface remains entirely smooth, but generally the pustules begin at a certain distance from the beaks, and are larger or smaller, rounded or transverse. Upon the posterior slope they are absent or present, and, when present, generally smaller, and often arranged in radiating ribs, or they are entirely rib-like. Epidermis yellowish brown to brown, when young, generally with distinct green rays, one of which is characteristically broad, sometimes interrupted so as to form blotches. Growth-rests dark brown.

Hinge-teeth heavy, more or less ragged. Pseudocardinals slightly divergent. Interdentum present, narrower or broader. Lateral teeth rather strong and short. Beak cavity rather deep. Dorsal muscle scars upon the hinge plate. Nacre always white. No difference whatever between the male and female shell.[28]

| | L. | H. | D. |
|---|---|---|---|
| *Size:* Kelly, Cat. No. 61.4365 (largest at hand, ♂) | 72 mm. | 70 mm. | 36 mm. |

[28] Call (1896*a*, p. 43) says that "the female is often somewhat emarginate." This is not always so in the females at hand; in fact this slight emargination of the posterior margin, which is actually often observed in this species, has no relation to sex.

*Soft parts* (See Ortmann, 1912, p. 251). *Glochidia* figured by Lefevre & Curtis (1910, p. 97, fig. F, and 1912, p. 146, fig. F), 0.23 × 0.32 mm.; by Surber (1912, Pl. 2, fig. 20) 0.23 × 0.29 mm., and by Howard (1914, Pl. 5, fig. 36). I have seen them in specimens from West Virginia and Arkansas, and found them to vary somewhat in size: 0.21 × 0.26 mm. (Arkansas), and 0.22 × 0.29 mm. (West Virginia). They are rather large for the genus.

*Breeding season:* Gravid females have never been observed in our state, but I have them from Arkansas, collected on May 19, 1911, and July 19, 1913, and from West Virginia, collected July 10, 1911. In the upper Tennessee region, I found them on May 25, 1914. This is probably a summer breeder (tachytictic).

*Remarks:* This species is well-distinguished by the general shape and sculpture, although the latter is often poorly developed and even absent (chiefly in young specimens). The sculpture always begins at a certain distance from the beaks, and does not represent a continuation of the beak-sculpture. In its general character, this sculpture resembles that of certain species of other genera, chiefly of *Plethobasus cooperianus* (Lea), and there are cases, where it is hard to distinguish these two species by the shell alone. However, *P. cooperianus* is generally more oblique, and the nodules are rather distinctly confined to the posterior half of the shell. Of course, they are easily told apart, when the soft parts are at hand.

The shells from the Ohio-drainage in Pennsylvania are undoubtedly all typical *Q. pustulosa*. But outside of our state this species varies greatly, not only in sculpture, but also in shape. These variations are in part geographical, and have been named, but cannot be discussed here.

*Localities in Pennsylvania, represented in the Carnegie Museum:*

Ohio River, Shippingport, Cooks Ferry and Industry, Beaver Co.; Neville Island, Allegheny Co.
Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Mahoning River, Mahoningtown and Edinburg, Lawrence Co.
Monongahela River, Westmoreland Co., and Charleroi, Washington Co. (G. A. Ehrmann).
Cheat River, Cheat Haven, Fayette Co.
Allegheny River, Natrona, Allegheny Co.; Godfrey and Kelly, Armstrong Co.

*Locality in Pennsylvania, represented in the Philadelphia Academy of Natural Sciences:*

Ohio River, Coraopolis, Allegheny Co. (S. N. Rhoads).

*Other localities, represented in the Carnegie Museum:*

*Ohio-Mississippi-drainage:*

Ohio River, Toronto, Jefferson Co., Ohio; St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.
Little Kanawha River, Grantsville, Calhoun Co. (F. W. Graham); Burnsville, Braxton Co., West Virginia.

Elk River, Shelton, Clay Co., West Virginia.

Pocatalico River, Raymond City, Putnam Co., West Virginia.

Little Coal River, Boone Co., West Virginia (Hartman collection).[29]

Levisa Fork Big Sandy River, Prestonsburg, Floyd Co., Kentucky.

Licking River, Farmer, Rowan Co., Kentucky.

Wabash River, New Harmony, Posey Co., Indiana (A. A. Hinkley).

Mississippi River, Muscatine, Muscatine Co., Iowa (Hartman collection); and Moline, Rock Island Co., Illinois (P. E. Noordgren).[30]

*Tennessee-drainage:*

Tennessee River, Florence, Lauderdale Co., and Tuscumbia, Colbert Co. (H. H. Smith); Bear Creek, Burleson, Franklin Co. (H. H. Smith); Shoals Creek, Lauderdale Co. (H. H. Smith); Paint Rock River, Paint Rock, Jackson Co., Alabama (H. H. Smith).

Tennessee River, Concord and Knoxville, Knox Co., Tennessee.

French Broad River, Boyd Creek, Sevier Co., Tennessee.

Nolichucky River, Chunns Shoals, Hamblen Co., Tennessee.

Holston River, McMillan and Mascot, Knox Co.; Hodges, Jefferson Co., Tennessee.

Clinch River, Solway, Knox Co.; Edgemoor, Clinton, and Offutt, Anderson Co., Tennessee.

Specimens from the Black River and Ouachita River in Arkansas do not represent the typical phase of *Q. pustulosa:* they require further study. (See: Wheeler, 1918, p. 123.)

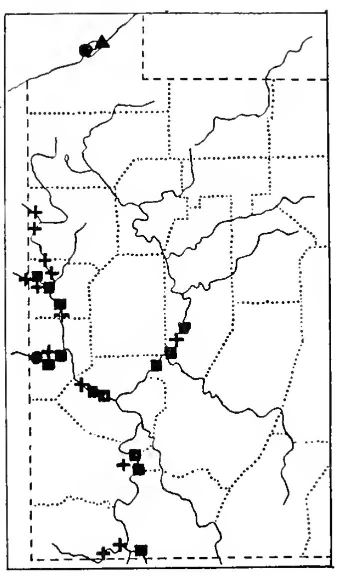

FIG. 5.

■ *Quadrula pustulosa.*
▲ *Quadrula pustulosa schoolcraftensis.*
● *Quadrula quadrula.*
+ *Quadrula verrucosa.*

[29] Labeled "Little Coal River, Logan Co., Virginia," but this river does not flow through Logan Co.

[30] The specimens from the Mississippi River differ somewhat from the typical form in having a better developed posterior wing and somewhat more prominent beaks, so as to intergrade toward *Q. dorfeuillana* (Lea).

*Distribution and Ecology in Pennsylvania* (See fig. 5): This is one of the rarer species in Pennsylvania. It occurs in the Ohio and Monongahela, in the latter as far up as the lower Cheat River, but it is missing in the headwaters of this system in West Virginia. In the Allegheny River, it has been traced up into Armstrong Co., and, in addition, it is found in the Beaver and Mahoning Rivers, but has not been found in the Shenango.

In all the other streams, not mentioned, it is absent, and thus its ecological preferences are decidedly with the larger streams; but since it has not often been found alive, details are scarce. I collected it myself in the heavy gravel of the Ohio, Allegheny, and Cheat, as well as in coarse gravel in the Mahoning. On similar bottom I found it in the Little Kanawha and Elk Rivers in West Virginia, and in the upper Tennessee region. But in Pocatalico River I found it in pure sand. In the Ohio in West Virginia and Ohio, it is abundant on the "shell banks," in deep, strongly flowing water, with gravelly bottom, and here it is frequently taken by the clam-diggers. Call (1900, p. 488) reports this species from muddy bottoms as well as from sand and gravel bars.

*General distribution: Type-locality,* Ohio (Lea). This species is quite characteristic of the Ohio proper and its larger tributaries. It also belongs to the Cumberland and Tennessee-drainages, and is there in its typical phase, but some confusion exists as to this.[31] In the states of Ohio, Indiana, and Illinois it is a common shell (Sterki, 1907*a*, Call, 1896*a*, and 1900, Baker, 1898*a* and 1906). How far it extends West and Southwest is hard to say, but the typical form has been figured by Scammon (1906) from Kansas. In this region, however, it is in part represented by more or less distinct varieties. Among the material at hand, there seem to be several of the latter, but I am well acquainted only with one (var. *schoolcraftensis*, see below).

*Note:* This species is only moderately swollen, or even rather flat, in Pennsylvania. Farther down the Ohio more distinctly swollen individuals are met with, becoming sometimes almost globular, culminating finally in the type known as *dorfeuillana* Lea (with high beaks). This indicates a tendency similar to that observed in several of the preceding species, which, however, is in this case not so distinctly marked, since *Q. pustulosa* does not go up, as a rule, into small streams.

[31] The chief mistake has been made by Simpson (1900, p. 780) in stating that the varieties *pernodosa* Lea and *kieneriana* Lea (not *keineriana* ) are found in streams "draining into the Gulf of Mexico," while the type-locality of *pernodosa,* at least, is in the upper Tennessee drainage. A singular double mistake is made by Sterki (1907*a*, p. 391) in quoting "*kleineriana*" (for *kieneriana*) from Lake Erie.

## Quadrula pustulosa schoolcraftensis (Lea) (1834).

*Quadrula pustulosa schoolcraftensis* (Lea) Simpson, 1914, p. 850.[32]

Plate III, figs. 6, 7.

Never before reported from Pennsylvania.

*Characters of variety:* Distinguished from typical *pustulosa* by the more transverse and subquadrate outline. This is brought about by a stronger development of the posterior wing, and the shell thus appears more elongated, and less high. In addition, the posterior ridge appears more distinct, the color of the epidermis is generally lighter, and the nodules are rather poorly developed, but the latter characters are inconstant.

| *Size:* | L. | H. | D. |
|---|---|---|---|
| 1. Erie, Pennsylvania, Cat. No. 61.4515 (old ♀, much elongated) | 72 mm. | 52 mm. | 36 mm. |
| 2. Cedar Point, Ohio, Cat. No. 61.4451 (normal) | 49 " | 41 " | 26 " |

*Soft parts* agreeing with those of the typical form (Ortmann, 1912, p. 251) *Glochidia* and *breeding season* not observed.

*Remarks:* The characteristic feature of this form, the transverse shape, has been sufficiently emphasized by the earlier authors, but later on it was unconditionally thrown together with *pustulosa* (Call, 1900; Simpson, 1900). Sterki (1907*a*, p. 291), however, has again correctly recognized it, and Simpson follows him (1914). I also believe that it is a distinguishable form, but there are intergrades with the normal *pustulosa*. In our region, *schoolcraftensis* is quite distinct, and does not come together geographically with the typical form. But this is the case elsewhere. Baker (1898*a*, Pl. 24 and 25) has given a number of figures, some of which are evidently *pustulosa*, but at least one is an undoubted *schoolcraftensis*. There are some figures on Baker's plates, which are more or less transitional between the two, and such specimens are also represented in the Carnegie Museum. An example is a fine large specimen from Kishwaukee River, Rockford, Winnebago Co., Illinois (P. E. Nordgren) (L. 64, H. 60, D. 43 mm.). In outline this specimen is intermediate, but on the other hand it is rather smooth and has higher beaks, but not as high as in *dorfeuillana*. In the latter character it resembles some specimens from the Mississippi, taken at Moline, Rock Island Co., Illinois (P. E. Nordgren) and from Muscatine, Iowa, but the latter are not so transverse. (I have recorded these under *pustulosa*.)

Intergrades certainly exist, and as far as I can see at present, they are found in Illinois. They may exist elsewhere. The opinion of Call, Baker, Scammon,

[32] *Unio prasinus* Conrad, made by Simpson a synonym of typical *Q. pustulosa*, belongs here.

and others, that these forms belong to the same species, surely is founded upon the observation of transitions, and I also think that *schoolcraftensis* should not be separated specifically, although the conditions in Pennsylvania would suggest such a step.

It should be mentioned that specimens from Lake Erie show the regular and distinct growth-lines, commonly observed in shells from Lake Erie.

*Localities represented in the Carnegie Museum:*

Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania.
Lake Erie, Cedar Point, Erie Co., Ohio (C. Brookover).
Lake Erie, La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).
Miami and Erie Canal, Waterville, Lucas Co., Ohio (C. Goodrich).
Maumee River, Defiance, Defiance Co., Ohio (C. Goodrich).
Grand River, Grand Rapids, Kent Co., Michigan (G. H. Clapp donor).
Coon River, Dallas Co., Iowa (Smith collection).
Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).
Hinkston Creek, Columbia, Boone Co., Missouri (D. K. Greger).
Platte River, Garretsburg, Buchanan Co., Missouri (W. I. Utterback).
Kansas and Wakarusa Rivers, Lawrence, Douglas Co., Kansas (R. L. Moodie).[33]
Chikaskia River, Tonkawa, Kay Co., Oklahoma (F. B. Isely).

In addition, there is a fine large specimen, labeled Poland, Mahoning Co., Ohio, and two others, labeled: Grand River, Ohio, all from the Hartman collection. Those from the latter locality were named *dorfeuillanus*, with the remark: "Lea datum," and thus they are supposed to be authentic specimens from Lea. But I believe, that these localities are unreliable. These specimens are so typically representative of the form from Lake Erie (with very distinct and regular growth-lines) that I think they are undoubtedly from the lake. The fauna of Grand River in Ohio is practically unknown. Poland is near the Mahoning River, and we know, that the typical *pustulosa* is found in the Pennsylvanian part of this river.[34]

*Distribution and Ecology in Pennsylvania* (See fig. 5): In Pennsylvania, this form has been found only in Presque Isle Bay of Lake Erie, in the characteristic fine sand of the "flats" and the North shore ("Big Bend") of the bay, where the shore is lined with the *Juncus americanus* formation, in one to two feet of water. It appears to be a rare shell there, since only two specimens have turned up.

*General Distribution: Type locality,* "Fox River of Green Bay" in Wisconsin (Lea). (This belongs to the Lake Michigan-drainage, and is at the same time the most northern locality known.)

From Lake Erie, this form has been reported before as *Q. pustulosa* (Walker, 1913). Aside from the localities given above for the lake, it is found in some of

[33] Some of these specimens, when received, were labeled (by Scammon?) *Quadrula rubiginosa*!

[34] Dean (1890) does not report *pustulosus* from the Mahoning in Ohio, nor does Sterki (1907*a*), but both have *pustulatus* Lea, which is a species not at all found in this region. Probably, Dean's *pustulatus* is only a slip of the pen for *pustulosus*.

the tributaries in Ohio (Tiffin River, Sterki, 1907*a*, and other places in the Maumee-drainage), and is known from the Kankakee in Indiana (Sterki),[35] from Michigan, Illinois, and Iowa (Sterki, 1907*a*, Walker, 1894, as *schoolcraftensis*, and 1898 as *pustulosa*). That it is found in Iowa, is confirmed by the locality given above, and by Call (1895), while Geiser (1910) reports only *pustulosa* from the Wapsipinicon River in northeastern Iowa. The specimens from Missouri and Kansas are fine and typical. Beyond this we do not know much about the distribution of this form, but it is apparent that this variety is more western and northern in its range than the typical *pustulosa*.

It should be noted that the form from Lake Erie hardly differs from the normal type of *schoolcraftensis*, except for the more regular and distinct growth-lines. The route by which it migrated into the lake is indicated by its presence in the Maumee-drainage.

### Quadrula quadrula (Rafinesque) (1820).

*Quadrula lachrymosa* (Lea) Simpson, 1914, p. 841; *Quadrula quadrula* (Rafinesque) Vanatta, 1915, p. 556; *Quadrula quadrula* (Rafinesque) Utterback, 1916, p. 53.

Plate IV, fig. 1.

*Records from Pennsylvania:*

Ortmann, 1909*b*, p. 199.

*Characters of the Shell:* Shell growing to a rather considerable size, rather heavy. Outline subtrapezoidal or subquadrate, not oblique, not longer, or only slightly longer than high. Beaks moderately prominent, beak-sculpture double-looped, posterior loop slightly tubercular upon the posterior ridge, these tubercles continued upon the ridge as larger or smaller nodules. Anterior loop, toward the disk, breaking up into nodules, and this sculpture is continued upon the disk in an irregular way. Shell moderately swollen or rather flat, with a rather distinct, but narrow, posterior ridge. In front of the latter, there is a broad, shallow furrow, which is generally smooth, without tubercles. There are large nodules upon the posterior ridge, and smaller ones upon the disk in front of the furrow, but the most anterior part of the shell is generally smooth. Nodules and tubercles very varying in number, arrangement, size, and shape; often they are tear-like (vertically elongated), but they may be transversely elongated. The nodules of the anterior part of the shell are the direct continuation of the beak-sculpture. Posterior slope with more or less distinct nodules, often arranged in radiating ridges.

[35] Specimens from the Kankakee River are cited as *pustulosa* by Wilson & Clark (1912*a*), but they mention the great variability.

Epidermis yellowish to brownish, when young with indistinct rays, and the green color of the rays often spreads out over the shell in indistinct transverse bands or patches (under the larger nodules), so that the whole surface often appears more or less suffused with green. But there are never triangular spots (as in *Q. metanevra* and *Q. cylindrica*). Growth-rests more or less distinct, brownish. Old shells often are uniformly brown, and the sculpture disappears toward the lower margin.

Hinge-teeth moderately strong. Pseudocardinals divergent, ragged; interdentum moderately developed. Beak-cavity moderately deep. Dorsal muscle-scars on hinge-plate. Nacre white. No differences between the male and female shell.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Cooks Ferry, Cat. No. 61.3869 | 72 mm. | 60 mm. | 36 mm. |
| 2. Erie, Cat. No. 61.4526 | 64 " | 52 " | 29 " |

This species grows considerably larger outside of Pennsylvania.

*Soft parts:* Ortmann (1912, p. 253). *Glochidia*, figured by Surber (1915, p. 8, pl. 1, fig. 11), remarkably small (0.085 × 0.090 mm.), much resembling those of *Q. verrucosa*. Howard (1914, pl. 5, fig. 29) also gives a figure.

*Breeding season:* Wilson & Clark (1912*a*, p. 43) report this species as found beginning to become gravid on August 21 in Illinois, and Surber found specimens with glochidia in August in Kansas.

*Remarks:* The broad, smooth furrow of the disk and the sculpture distinguish this species sufficiently from all other Pennsylvanian forms. The sculpture is very variable, sometimes rather slightly developed, in other cases strong and very prominent. Only a few specimens having been found in our state, no important variations are to be noted. The color-pattern of this species, although quite variable, is characteristic in so far that the rays never break up into well-defined spots.

*Localities in Pennsylvania, represented in the Carnegie Museum:*

Ohio River, Cooks Ferry, Beaver Co.
Lake Erie, Presque Isle Bay, Erie, Erie Co.

*Other localities represented in the Carnegie Museum:*

Miami-Erie Canal, Lucas Co., Ohio (C. Goodrich).
Ohio River, St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portsmouth, Scioto Co., Ohio.
Middle Island Creek, Union Mills, Pleasants Co., West Virginia.
Wolfe Creek, Wolfe P. O., Washington Co., Ohio (W. F. Graham).
West Fork White River, Riverside, Greene Co., Indiana (J. D. Haseman).
Wabash River, New Harmony, Posey Co., Indiana (A. A. Hinkley).

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).
Mississippi River, Muscatine, Muscatine Co., Iowa (Hartman collection).
Sheyenne River, Argusville, Cass Co., North Dakota (S. M. Edwards).
Hinkston Creek, Columbia, Boone Co., Missouri (D. K. Greger).
Platte River, Garretsburg, Buchanan Co., Missouri (W. I. Utterback).
Lake Contrary, St. Joseph, Buchanan Co., Missouri (W. I. Utterback).[36]
Wakarusa River, Lawrence, Douglas Co., Kansas (R. L. Moodie).
Chikaskia River, Tonkawa, Kay Co.; North Fork Canadian River, Weleetka, Okfuskee Co.; Deep Fork Canadian River, Okmulgee, Okmulgee Co., Oklahoma (F. B. Isely).

*Distribution and Ecology* (See fig. 5). *Type locality:* Ohio River (Rafinesque) according to Vanatta, Salt River, Kentucky.

Two specimens only have been found in Pennsylvania; one in the Ohio River, just above the Ohio state line, the other in Lake Erie. The first was found in sandy-muddy bottom in a quiet eddy in a riffle, the second (a dead shell) in fine sand, the environment characteristic of Presque Isle Bay. According to Baker (1898*a*, p. 85) this species prefers the muddy and sandy bottoms of lakes and larger rivers, and Call (1900, p. 490) calls it a mud-inhabiting shell, while Scammon (1906, p. 252) says that in Kansas it is not particular as to station, but prefers sand. Apparently, it does not find congenial habitats in Pennsylvania, except in Lake Erie and in the Ohio. Its utmost upstream migration has barely reached our state.

Farther down the Ohio, it is also not very abundant, but it is present. In the slack water of the lower part of Middle Island Creek, I have seen a number of dead shells, and here it goes up as far as the slack water, about 5 miles, to just below Union Mills. Also farther down it is not abundant, and distinctly prefers sandy or muddy bottom to gravel. It does not ascend far into the tributaries, but it goes into the lower Muskingum and to Wolfe Creek. It is not in the Tuscarawas, according to Sterki (1907*a*, p. 390). In western Ohio and in southern and northwestern Indiana it is more widely distributed. Here it crosses over into the Lake Erie-drainage (Ohio Canal, Sterki), and into the lake (Sterki, and Walker, 1913). It occurs also in Beaver Creek, Lorain, Lorain Co., Ohio (Dall & Simpson, 1895), and in Michigan (Walker). It extends westwards and southwards to Minnesota, Iowa, Kansas, Oklahoma, northeastern Texas, and northern Louisiana. It also crosses over into the drainage of the Red River of the North (Winnipeg, Canada). There are no records from south of the Ohio, but the Carnegie Museum has it from the Tennessee in northern Alabama. From Alabama, there is only a single, doubtful and indefinite, previous record (Call).

Thus it seems that the center of this species is in the Mississippi and lower Ohio.

[36] This is the var. *contraryensis* of Utterback, a local phase.

Its absence in the Cumberland and upper Tennessee is remarkable, but probably accounted for by its ecological habits. On the Gulf plain, it is largely represented by other allied species.

Sterki says that the Lake Erie form is "little inflated and has few tubercles." This fits the specimen before me, but I cannot judge from a single example whether this is a constant difference.

### Quadrula verrucosa (Rafinesque) (1820).

*Tritogonia tuberculata* (Barnes) Simpson, 1914, p. 318; *Tritogonia verrucosa* (Rafinesque) Vanatta, 1915, p. 554; *Quadrula verrucosa* (Rafinesque) Utterback, 1916, p. 62.

Plate IV, figs. 2, 3.

*Records from Pennsylvania:*

Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver River, Wampum, Lawrence Co.).
Ortmann, 1909*b*, p. 198.

*Characters of Shell:* Shell large and heavy. Outline elongate-subtrapezoidal, considerably longer than high. Beaks low. Beak-sculpture consisting of one or two subconcentric bars, curving upwardly and nodular behind, followed by additional bars, which are more or less distinctly double-looped, and break up into nodules, which are indistinctly arranged in zig-zag waves. This sculpture is continued upon the disk. Shell moderately swollen or rather flat, with a distinct, but narrow posterior ridge. In front of the latter the sides of the shell are flattened or somewhat concave, thus forming a broad, shallow radial groove. The posterior nodular part of the beak-sculpture is continued upon the posterior ridge as a row of tubercles, which, however, are not very prominent, and gradually disappear. In front of the posterior ridge the disk, including the groove, is thickly studded with rather small, low tubercles, which are often more or less distinctly arranged in diagonal rows, and represent the continuation of the beak-sculpture. Toward the lower margin, these tubercles become irregular, and may disappear. Posterior slope with ribs radiating from the posterior ridge; they are small, irregular, and nodulous toward the beaks, but become larger toward the posterior end of the shell. Epidermis yellowish to rusty brown and blackish, without distinct rays, but generally suffused with green in irregular patches. Often the whole surface is greenish, and only the tubercles are more or less yellowish or brownish. Growth-rests more or less distinct. Old shells are generally uniformly dark brown or blackish.

Hinge-teeth well-developed, strong. Pseudocardinals divergent, large, ragged. Interdentum moderately developed. Lateral teeth long, straight, rather heavy.

Beak-cavity not very deep. Dorsal muscle-scars on the hinge-plate. Nacre white.[37]

In this species, we meet with a more or less distinct sexual difference in the shell, unusual in the subfamily *Unioninæ*. In the male the posterior margin of the shell is short and subtruncate, and the ribs of the posterior slope are generally well-developed and continued to the margin. In the female the posterior margin is broadened and flattened in the region of the posterior angle, and the ribs of the posterior slope are poorly developed and broadened, so that the posterior end of the shell appears expanded. This expansion corresponds to the location of the anal opening in the soft parts.

| | | L. | H. | D. |
|---|---|---|---|---|
| *Size:* | 1. Edinburg, Cat. No. 61.3577 (sex doubtful) | 156 mm. | 86 mm. | 43 mm. |
| | 2. Mahoningtown, Cat. No. 61.3574 (♂) | 121 " | 70 " | 44 " |
| | 3. Pulaski, Cat. No. 61.4548 (♀) | 130 " | 64 " | 37 " |

No. 1 is the largest specimen from Pennsylvania, but larger ones are known from elsewhere. Scammon (1906) gives 168 as maximum length.

*Soft parts* (See Ortmann, 1912, p. 254). The *glochidia* have been figured by Surber (1912, Pl. 2, fig. 31). They are unusually small, 0.085 × 0.100 mm.

*Breeding season:* Sterki (1907*b*, p. 48) collected gravid females on June 10, 1907, and Surber gives April to June. I did not find any gravid females in Pennsylvania, but collected some on May 9, 1913, in Pocatalico River, and on May 23, 1912, in West Fork River, West Virginia. All these had eggs only, filling all four gills, forming lanceolate, not very solid, white placentæ. Those from Pocatalico River (two specimens) had the eggs brownish, discolored, and they were being discharged when opened (about two hours after capture). This was apparently premature discharge, and the eggs were dead (suffocated).

*Remarks:* This species has a very characteristic outline and sculpture. The latter, however, is quite variable. The tubercles of the disk may be larger or smaller, regular or irregular in size, rounded, subtriangular, or even vertically elongated. The ribs of the posterior slope are also variable, and more or less distinct. Toward the lower margin, the sculpture often disappears, and in some individuals the whole lower half of the shell may be smooth. The most remarkable fact in this species is the sexual differentiation of the shell, which has led Simpson to the opinion that it should represent a separate genus (*Tritogonia*). However, as I have shown, in all other characters, chiefly those of the soft parts, it is a true *Quadrula*. The posterior dilatation of the shell in the female is in an entirely different region from that in the females of the *Lampsilinæ*.

[37] In Pennsylvania, the nacre is always white; in the South (Alabama, etc.) it may be purple.

The sexual differences are sometimes quite striking, but not always so. It is by no means "one of the easiest species in which to distinguish the sexes," as Scammon (1906, p. 314) says. In the largest specimen, mentioned above, I am in fact in doubt whether it is a male or a female, and it is true that sometimes in large males (determined by the soft parts), the posterior end of the shell is somewhat expanded, with less developed ribs. But, as a rule, in individuals of medium and large size, the sex may be easily told from the shape of the shell. In young shells this is very hard, or even impossible to do.

It should be mentioned that the female shell is on the average more flattened and compressed than that of the male. This also is a rather unusual feature.

*Localities in Pennsylvania, represented in the Carnegie Museum:*

Ohio River, Industry, Beaver Co.
Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Mahoning River, Mahoningtown, Coverts, and Edinburg, Lawrence Co.
Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Sharpsville, Mercer Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Monongahela River, Charleroi, Washington Co. (G. A. Ehrmann).
Dunkard Creek, Wiley and Mount Morris, Greene Co.
Allegheny River, Kelly, Armstrong Co.

*Locality in Pennsylvania, represented in the Philadelphia Academy of Natural Sciences:*

Ohio River, Coraopolis, Allegheny Co. (S. N. Rhoads).

*Other localities represented in the Carnegie Museum:*

*Ohio-drainage:*

Tuscarawas River, Ohio (Holland collection).
Wolfe Creek, Washington Co., Ohio (W. F. Graham).
West Fork White River, Riverside, Greene Co., Indiana (J. D. Haseman).
West Fork River, Lynch Mines, Harrison Co.; West Milford, Harrison Co. (W. F. Graham); Lightburn, Lewis Co., West Virginia.
Little Kanawha River, Burnsville, Braxton Co., West Virginia.
Pocatalico River, Raymond City, Putnam Co., West Virginia.
Elk River, Sutton and Gassaway, Braxton Co., West Virginia.
New River, Hinton, Summers Co., West Virginia.
Levisa Fork Big Sandy River, Prestonsburg, Floyd Co., Kentucky.
Licking River, Farmer, Rowan Co., Kentucky.

*Tennessee-drainage:*

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).
Shoals Creek, Lauderdale Co., Alabama (H. H. Smith); Elk River, Fayetteville, Lincoln Co., Tennessee (H. H. Smith); Hurricane Creek, Gurley, Madison Co., Alabama (H. E. Wheeler); Paint Rock River, Trenton and Princeton, Jackson Co., Alabama (H. H. Smith); Bear Creek, Burleson, Franklin Co., Alabama (H. H. Smith).

*West of Mississippi:*

Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).
Black River, Black Rock, Lawrence Co., Arkansas (H. E. Wheeler).
White River, Cotter and Norfolk, Baxter Co., Arkansas (A. A. Hinkley).
Saline River, Benton, Saline Co., Arkansas (H. E. Wheeler).
Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).
Illinois River, Talequah, Cherokee Co., Oklahoma (F. B. Isely).
Bayou Pierre, De Soto Parish, Louisiana (L. S. Frierson).

*Mississippi, Alabama, Georgia:*

Pearl River, Mississippi (Juny collection).
Buttahatchee River, Hamilton, Marion Co., Alabama (H. H. Smith).
Sipsey River, Texas, Marion Co.; Fayette, Fayette Co.; and Elrod, Tuscaloosa Co., Alabama (H. H. Smith).
Forks of Black Warrior River, Walker Co., and Black Warrior River, Squaw Shoals, Jefferson Co., Alabama (H. H. Smith).
Valley Creek, Toadvine, Jefferson Co., Alabama (H. H. Smith).
North River, Haglers Mill, Tuscaloosa Co., Alabama (H. H. Smith).
Cub Creek, Pine Hill, Wilcox Co., Alabama (H. H. Smith).
Cahaba River, Gurnee, Shelby Co., Alabama (H. H. Smith).
Coosa River, Wetumpka, Elmore Co.; Weduska Shoals, Shelby Co.; Riverside, St. Clair Co., Alabama (H. H. Smith).
Choccolocco Creek, Calhoun Co., Alabama (H. H. Smith).
Oostanaula River, Rome, Floyd Co., Georgia (G. H. Clapp donor).
Conasauga River, Whitfield Co., Georgia (H. H. Smith).

*Distribution and Ecology in Pennsylvania* (See fig. 5): In Pennsylvania this species is rather local and not widely distributed. In the Ohio, Monongahela, and Allegheny, it is rather scarce, and only isolated specimens turn up. In the drainage of the Beaver it is a little more frequent, and the best places are at Edinburg and Pulaski. This would indicate, that the species prefers smaller rivers, which is substantiated by the fact that it is rather abundant in the headwaters of the Monongahela, in Dunkard Creek in Pennsylvania, and in West Fork River in West Virginia. In the upper Little Kanawha and in Elk River, West Virginia, it is also frequent.

This shell is found in coarse or fine gravel, generally not very deeply buried, but young shells are often found in fine sand and even in mud. In a mill-race of the Mahoning, at Edinburg, among heavy rocks, about a dozen were collected, all very large and ponderous. The best places are riffles with strong currents, interrupted by patches of *Dianthera americana*.

Scammon (1906, p. 314) reports this species in various ecological surroundings, but says it prefers gravel and shingle, with a swift current, while Call (1900, p. 465) says that it delights in muddy bottoms, which is surely not the case in Pennsylvania.

*General distribution: Type locality,* Ohio River (Rafinesque).

Simpson (1900) gives as the range of this species: "Mississippi-drainage generally; streams falling into the Gulf of Mexico from the Alabama system west to central Texas." This indicates a very wide distribution. In the Mississippi it goes into Wisconsin (Barnes, 1823; Lapham, 1860), and southern Minnesota (Grant, 1886; Holzinger, 1888), but its northward extension is generally rather restricted. Call (1895, p. 55) reports it from western New York, which is unconfirmed, and is very questionable, judging from its absence in the headwaters of the Allegheny in Pennsylvania, and its entire absence from the whole lake-drainage in Pennsylvania, Ohio (Sterki, 1907*a*), Indiana (Call, 1896*a*) and Illinois (Baker, 1906). As our records show, it occurs in the tributaries of the Ohio in West Virginia and Kentucky, and goes up the Tennessee to northern Alabama, but is absent from the upper Tennessee region, except the Hiwassee River. Westward it goes to Iowa, Kansas, and Oklahoma, and its occurrence in Arkansas, and in the Gulf-drainage from Georgia to Texas is well established.

This species seems to belong more to the south and the west, but it has ascended the Mississippi to a considerable distance, and the Ohio practically throughout its whole drainage, except the smallest headwaters in the north and east.

It does not seem to be very abundant in the larger streams. I never found it in the Ohio proper below the Pennsylvania state-line, although it is in the Cincinnati list of shells.

### Quadrula metanevra (Rafinesque) (1820).

*Quadrula metanevra* (Rafinesque) Simpson, 1914, p. 834.

Plate IV, figs. 4, 5, 6.

*Records from Pennsylvania:*

Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co.).
Ortmann, 1909*b*, p. 198.

*Characters of the shell:* Shell of medium size, heavy. Outline subtrapezoidal, subrhomboidal, or subquadrate, sometimes subtriangular, short, not longer, or very little longer, than high. Beaks moderately elevated. Beak-sculpture consisting of two or three subconcentric bars, which are angular and nodulous upon the posterior ridge; anterior part rather straight, and curved upward in front, thick, but not sharply marked. The nodulous portion is repeated upon the posterior ridge in the shape of tubercles, while the anterior part of the following bars becomes indistinct, and is soon supplanted by the sculpture of the disk. Occasionally the third and fourth bars show an indication of double-looped structure, and sometimes

even traces of a breaking up into small zig-zag nodes is seen. In certain other cases the beak-sculpture is separated from that of the disk by a smooth space. Shell sometimes rather flat, but generally more or less swollen, with a broad, distinct, and prominent posterior ridge. In front of the ridge, the shell is flat or depressed, but without forming a distinct radiating furrow. The posterior nodular part of the beak-sculpture is continued upon the ridge as large and distinct prominent tubercles or nodes, standing rather remote from each other; sometimes these nodes are broken up into clusters of nodules, and in rare cases they are rudimentary or absent. In front of the posterior ridge the shell is covered by larger or smaller nodules, very irregular and variable in arrangement, shape, and number. Sometimes there are very few, in other cases very many of them, but toward the lower margin they generally tend to disappear in larger shells, and the anterior part of the disk is always smooth. Towards the beaks, the nodules are smaller, and may disappear, or pass into the beak-sculpture. Posterior slope generally marked off from the posterior ridge by a narrow furrow, producing an emargination of the posterior margin, and its surface may be smooth, or tuberculated, or radiately ribbed. Epidermis yellowish to brownish black, with a characteristic greenish color-pattern: the rays are broken up into triangular spots of larger or smaller size, pointed toward the lower margin. These color-patches are very variable, sometimes almost absent, sometimes very distinct, chiefly so in young specimens; in older ones they become obliterated, the epidermis appearing uniformly brownish. Regular linear rays are sometimes present, but not often. Growth-lines more or less distinct.

Hinge-teeth well-developed, strong. Pseudocardinals divergent, large, ragged. Interdentum present, generally well-developed. Lateral teeth strong, of medium length. Beak-cavity deep or moderately deep. Dorsal muscle-scars on the hinge-plate. Nacre always white.

Sexes absolutely indistinguishable in the shell.

| *Size:* | L. | H. | D. |
|---|---|---|---|
| 1. Industry, Cat. No. 61.3866 (largest from Pennsylvania) | 90 mm. | 71 mm. | 47 mm. |
| 2. Kelly, Cat. No. 61.3861 (very flat) | 89 " | 70 " | 36 " |
| 3. Aladdin, Cat. No. 61.3868 (normal) | 67 " | 58 " | 38 " |

*Soft parts* (See Ortmann, 1912, p. 255, fig. 6). *Glochidia* figured by Lefevre & Curtis (1910, p. 97, fig. E, and 1912, p. 146, fig. E), by Surber (1912, Pl. 2, fig. 26), and Howard (1914, Pl. 5, fig. 31). Their measurements have been given as $0.18 \times 0.19$ mm. and $0.175 \times 0.200$ mm. I have not seen glochidia in Pennsylvania, but have found them in the flat form (var. *wardi*) from the Little Kanawha

River, West Virginia. The shape was the same, as reported, but they were slightly larger: 0.20 × 0.22 mm. I have repeatedly found specimens with eggs and with distinct placentæ; but when glochidia are present, the placentæ easily fall apart.

*Breeding season:* The specimen with glochidia was found on May 24, 1911, and a specimen with eggs was collected on June 22, 1909. Other specimens with eggs were received from Arkansas, collected on June 26, 1911. The early date for glochidia is remarkable. It is astonishing, on the other hand, that among numerous specimens collected on June 20, 21, and 22, 1911, in the Ohio River at St. Marys, West Virginia, no gravid females were found. The species surely is tachytictic; Surber (1912, p. 7) gives May to July as the breeding season.

*Remarks:* It is hardly possible to mistake this species on account of its marked shape and sculpture. Yet there is quite a range of variation, chiefly with regard to obesity of the shell, and to sculpture. As is seen in the measurements given above, some shells are considerably more flattened, and it is to be noted that such specimens are more frequent in the Allegheny than in the Ohio. This would express the same tendency toward flattening of the shell in smaller rivers, which we have noticed in several of the foregoing species. But in this case it is impossible to distinguish a flat race, since there are all intergrades, and only few flat individuals are found, always associated with others which are swollen (See Pl. IV, figs. 4, 5, 6).

In the development of the tubercles we notice an important variation in which the large tubercles of the posterior ridge are obliterated. Such specimens, which at the same time were rather flat, have been described by Lea (Obs. IX, 1863) as a separate species, *Unio wardi* (from Walhonding, Ohio; Wapsipinicon, Iowa; and Coal River, West Virginia).[38] Three specimens from the latter locality are in the Carnegie Museum, derived from the Hartman collection. They undoubtedly are the same specimens referred to by Lea, as being in the Hartman collection. They agree very well with Lea's figure, but the posterior ridge is not entirely smooth, although without the large tubercles. I have specimens like these from the Little Kanawha River and from the West Fork River. These also are remarkably flat. Finally specimens resembling these are sometimes found in western Pennsylvania (See Pl. IV, fig. 6). The second one, of which the measurements are given (from Kelly), should be by all means regarded as *wardi* and there is a half shell from the Monongahela at Charleroi, which has been labeled by Simpson as var. *wardi*, and rightly so. Compressed specimens, which also have the tubercles more or less obliterated, have been found occasionally all the way down from the

[38] Lea says: "Coal River, Logan Co., Va.," but Coal River and Little Coal River are today in Kanawha and Boone Cos., West Virginia.

Allegheny, Armstrong Co., Pennsylvania to Parkersburg, West Virginia, but in company with the normal form. They should be called *wardi*, but do not form a distinct race, but are rather individual variations.

It is interesting to note, that outside of our state, nearly all specimens from small rivers and creeks, such as West Fork River, the Little Kanawha, and Coal

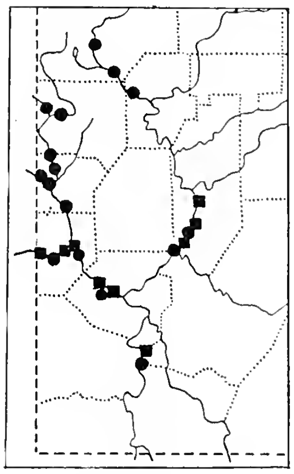

Fig. 6.

■ *Quadrula metanevra.*

● *Quadrula cylindrica.*

River, belong to this form called *wardi*, and it may be, that in such small streams, the *wardi*-type becomes the prevailing one, thus forming an ecological race. Sterki (1907*a*, p. 390) mentions such a case from Sugar Creek, a small tributary of the Tuscarawas River in Ohio.

*Localities in Pennsylvania, represented in the Carnegie Museum:*

Ohio River, Shippingport, Cooks Ferry, and Industry, Beaver Co.; Coraopolis (S. N. Rhoads) and Neville Island, Allegheny Co.

Allegheny River, Aladdin, Godfrey, Johnetta, Kelly, and Templeton, Armstrong Co.

Monongahela River, Charleroi, Washington Co. (G. A. Ehrmann).

*Locality in Pennsylvania, represented in the Philadelphia Academy of Natural Sciences:*

Ohio River, Beaver, Beaver Co. (S. N. Rhoads).

*Other localities represented in the Carnegie Museum:*

*Ohio-drainage:*

Ohio River, Toronto, Jefferson Co., Ohio; Wheeling, Ohio Co., West Virginia (W. F. Graham); Clarington, Monroe Co., Ohio; St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.

West Fork River, West Milford, Harrison Co., West Virginia (W. F. Graham).

Little Kanawha River, Grantsville, Calhoun Co. (W. F. Graham), and Burnsville, Braxton Co., West Virginia.

Coal River and Little Coal River, Boone Co., West Virginia (Hartman collection).[39]

*Tennessee-drainage:*

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith); Knoxville, Knox Co., Tennessee.

Paint Rock River, Paint Rock, Jackson Co., Alabama (H. H. Smith).

Holston River, Mascot, Knox Co., Tennessee.

*Mississippi-drainage and westward:*

Peoria Lake, Illinois River, Illinois (Hartman collection).

Mississippi River, Muscatine, Muscatine Co., Iowa (Hartman collection).

Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).

Black Rock River and Spring River, Black Rock, Lawrence Co., Arkansas (H. E. Wheeler).

Spring River, Williford, Sharp Co., Arkansas (H. E. Wheeler).[40]

White River, Cotter, Baxter Co., Arkansas (A. A. Hinkley).

Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).

Neosho River, Miami, Ottawa Co., Oklahoma (F. B. Isely).

*Alabama-drainage:*

Sipsey River, Texas, Marion Co., Alabama (H. H. Smith).

Coosa River, Wilsonville, Shelby Co., and Riverside, St. Clair Co., Alabama (H. H. Smith).

*Distribution and Ecology in Pennsylvania* (See fig. 6): In Pennsylvania this species is restricted to the three large rivers, the Ohio, Allegheny, and Monongahela. In the Allegheny it goes up a little beyond the middle of Armstrong County. From the Monongahela it is known only from one locality, but it must have at one time ascended into West Virginia, for it occurs in the West Fork River.

Wherever found it is not rare, but it is most abundant in the Ohio below Pittsburgh. Here it favors the same places as most other species: coarse gravel in swiftly running water, and it helps to compose the shell-banks, where such are present (at Shippingport and Industry). This agrees with Scammon (1906, p. 350), who says that gravel-bars are its favorite habitat. In the Ohio below Wheeling it is frequently taken by the clam-diggers out of deep water in strong and steady currents.

*General distribution: Type locality,* Kentucky River (Rafinesque).

The general distribution, as given by Simpson (1900) is: "Mississippi-drainage area, except its southern portion, extending to the Tennessee and Arkansas River." This is quite correct, and it is to be particularly noted, that toward the east and north, this species does not cross over into any other drainage-system. As we have seen, in western Pennsylvania it does not advance far up into small streams,

[39] See above p. 49. Specimens from West Fork, Little Kanawha, and Coal Rivers all (together six) represent the form *wardi*.

[40] This specimen is a good representative of the var. *wardi*.

and the same seems to be true elsewhere, although there are a few exceptions, and it seems that in such cases the main form tends to be replaced by the variety *wardi*.

In Ohio the main species hardly occurs outside of the Ohio proper (Sterki, 1907*a*). In Indiana it is known only from the larger rivers, the Ohio, White, Wabash, and Kankakee, and also from Eel, Blue, and Whitewater Rivers (Call, 1896 and 1900). In Illinois the same rule seems to prevail, so that its range covers the greater part of the state, except the northern and northeastern extremity (Baker, 1906; Wilson & Clark, 1912*a*). In the Mississippi-drainage, this species goes up into the Wisconsin River in Wisconsin, and the Minnesota River in Minnesota.

Westwards it is found as far as southeastern Kansas (Scammon, 1906) and to the southwest it extends to Oklahoma and the Ouachita River in Arkansas (Call, 1895; Wheeler, 1918, and our own material). The records from Louisiana and Texas are doubtful.

South of the Ohio in West Virginia this species is found in the headwaters of the Monongahela (West Fork River), in the Little Kanawha, and in Coal River, but, according to specimens in the Carnegie Museum, in the form *wardi*. Records from Kentucky and Tennessee are scanty. The type-locality is the Kentucky River. It is known from the Cumberland River (Scammon, 1906, and Wilson & Clark, 1914) and our material shows its presence in the Tennessee up to the lower Holston (See also Lewis, 1871). It turns up again in the Alabama system (Lewis, 1877, Call, 1885, Carnegie Museum). Lea's locality (Obs. 10, 1863, p. 430), Columbus, Lowndes Co., Mississippi, belongs with this group of stations.

This latter set of localities is interesting, in view of Simpson's statement, that it is missing in the lower Mississippi region. If this is correct, it could have reached the Alabama-drainage only by crossing over from the Tennessee-drainage. This case should be kept in mind, for it is of zoögeographical importance.

### QUADRULA CYLINDRICA (Say) (1817).[41]

*Quadrula cylindrica* (SAY) SIMPSON, 1914, p. 832.

Plate V, figs. 1, 2, 3.

*Records from Pennsylvania:*

Harn, 1891, p. 136 (western Pennsylvania).

Rhoads, 1899, p. 136 (Ohio River, Coraopolis, Allegheny Co.; Beaver, Beaver Co.; and Beaver River, Wampum, Lawrence Co.).

Ortmann, 1909*b*, p. 198.

*Characters of the shell:* Shell rather large, heavy. Outline elongated sub-

[41] Not 1816 (See footnote 20 under *Amblema plicata*, p. 25).

trapezoidal, or almost rectangular, considerably longer than high. Beaks moderately prominent. Beak-sculpture consisting of a number of bars, the first of which seems to be simple, the following two or three distinctly double-looped, with the posterior loop angular and nodose upon the posterior ridge. Farther on, upon the disk, the nodes of the posterior loop are continued as strong tubercles, while the anterior loop breaks up into small granules, which generally assume a zigzag arrangement. They are continued downward to a variable extent, but generally they soon disappear. Shell greatly swollen, from almost subcylindrical to rather flat, with a broad and distinct posterior ridge. In front of the ridge the shell is flattened, but has no radial furrow; behind the ridge the shell is more or less depressed, thus generally producing a slight emargination of the posterior margin. Upon the posterior ridge stands a row of tubercles (continuing the beak-sculpture), which increase in size toward the posterior angle, and may be larger or smaller; in some cases they are more or less obliterated. In front of the posterior ridge the shell is generally smooth, but towards the beaks we find a number of small tubercles or nodules, described above as a continuation of the broken-up anterior loops of the beak-sculpture. The development of these nodules is quite variable. The posterior slope may be ornamented with ridges or radiating rows of nodules, or may be entirely smooth. Epidermis yellowish to brownish or greenish, with dark green rays broken up into a characteristic pattern of triangular spots, pointed toward the lower margin. The distribution and size of these spots is rather irregular and variable, but they are generally well-developed and distinct, and only in rare cases do they become obliterated. Linear rays are, as a rule, entirely absent, indications of them are seldom seen upon the posterior ridge or posterior slope.

Hinge-teeth well-developed, but not very heavy. Pseudocardinals divergent, ragged. Interdentum narrow or almost absent. Lateral teeth long. Beak-cavity moderately deep. Dorsal muscle-scars on the hinge-plate. Nacre always white.

Sexes absolutely indistinguishable in the shell.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Utica, Cat. No. 61.3852 (without any nodes).... | 123 mm. | 50 mm. | 45 mm. |
| 2. Meadville, Cat. No. 61.3850 (without any nodes). | 119 " | 54 " | 36 " |
| 3. Godfrey, Cat. No. 61.4358 (with strong nodes) .. | 83 " | 33 " | 33 " |
| 4. Aladdin, Cat. No. 61.3856 (with strong nodes) .. | 84 " | 37 " | 30 " |

Pennsylvanian specimens compare favorably with previous measurements; in fact, the size of the first one given represents the maximum on record.

*Soft parts* (See Ortmann, 1912, p. 256). It is to be added that gravid females

have been observed subsequently. All four gills are used as marsupia. The eggs form placentæ of lanceolate shape, of a peculiar yellow-brown or pale orange color. *Glochidia* have been observed in specimens from Holston River in Tennessee. Their shape is subcircular; length and height about 0.19 mm. Thus they resemble those of *Q. metanevra* ($0.18 \times 0.19$), but they are more nearly circular.

*Breeding season:* Gravid females were found on May 22, 1914; May 23, 1914; May 24, 1911; May 25, 1914; July 8, 1913. Glochidia were observed on May 23. The species apparently is bradytictic, as usual in the genus, but the date for glochidia is rather early. Wilson & Clark (1914) found gravid specimens in the Cumberland in June and July.

*Remarks:* This is an eminently characteristic species. The chief variations observed concern the general shape of the shell and the sculpture. The typical shape is "subcylindrical," with the height about the same, or nearly the same, as the diameter (see measurements of Nos. 1 and 3, above), but there are rather flat individuals. Sterki (1907*a*, p. 390) calls attention to a form from the Tuscarawas River, which lacks the tubercles of the posterior ridge. This form is the prevailing one in western Pennsylvania, and is most abundant in the Beaver drainage and in French Creek. I have many specimens in which no trace of the tubercles is seen, and generally also the smaller nodules of the anterior part of the shell near the beaks and the sculpture of the posterior slope are absent in them, so that the shell appears absolutely smooth. Yet there are all sorts of intergrades, connecting this smooth with the normal form (See Pl. V, figs. 2, 3). Farther down in the Ohio this smooth form is not found. These conditions are to a degree parallel with those observed in *Q. metanevra* and its var. *wardi*.

Very often the degree of obesity of the shell is correlated with the development of the sculpture, so that smooth specimens are at the same time unusually compressed. But this is not always the case, and smooth individuals may be subcylindrical, as our No. 1 (See measurements) and sculptured individuals may be somewhat compressed (See No. 4).

This smooth, and sometimes compressed form of the headwaters is so far known only from the Tuscarawas River in Ohio, from Beaver River and French Creek, in Pennsylvania, and from the upper Monongahela (West Fork River) in West Virginia.

It should be mentioned in this connection that a similar, compressed form is known from the headwaters of the Clinch River, in Virginia. This is the var. *strigillata* (Wright), but it is not a smooth form. On the contrary it is covered by a multitude of small tubercles. But here also the large tubercles of the posterior ridge are absent.

*Localities in Pennsylvania, represented in the Carnegie Museum:*

Ohio River, Shippingport, Cooks Ferry, and Industry, Beaver Co.
Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Mahoning River, Mahoningtown, Coverts, and Edinburg, Lawrence Co.
Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Clarksville and Shenango, Mercer Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Allegheny River, Aladdin, Godfrey, Johnetta, and Kelly, Armstrong Co.
French Creek, Utica, Venango Co.; Cochranton and Meadville, Crawford Co.
Monongahela River, Charleroi, Washington Co. (G. A. Ehrmann).

*Localities in Pennsylvania, represented in the Philadelphia Academy of Natural Sciences:*

Ohio River, Beaver, Beaver Co., and Coraopolis, Allegheny Co. (S. N. Rhoads).

*Other localities represented in the Carnegie Museum:*

*Ohio-drainage:*

Ohio River, Toronto, Jefferson Co., Ohio; Parkersburg, Wood Co., West Virginia; Portsmouth, Scioto Co., Ohio.
Tuscarawas River, Ohio (Holland collection).[42]
West Fork River, West Milford, Harrison Co., W. Va. (W. F. Graham).[43]
Little Kanawha River, Grantsville, Calhoun Co. (W. F. Graham), and Burnsville, Braxton Co., West Virginia.

*Tennessee-drainage:*

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).
Bear Creek, Burleson, Franklin Co., Alabama (H. H. Smith).
Paint Rock River, Paint Rock, Trenton, and Princeton, Jackson Co., Alabama (H. H. Smith).
Holston River, McMillan and Mascot, Knox Co.; Hodges, Jefferson Co.; Turley Mill and Noeton, Grainger Co.; Austin Mill and Church Hill, Hawkins Co., Tennessee.
North Fork Holston River, Rotherwood, Hawkins Co., Tennessee.
Big Mocassin Creek, Mocassin Gap, Scott Co., Virginia.
Clinch River, Edgemoor and Clinton, Anderson Co.; Clinch River Station, Claiborne Co., Tennessee; Speers Ferry and Clinchport, Scott Co., Virginia.[44]
Powell River, Combs, Claiborne Co., Tennessee.

*West of the Mississippi:*

Black River, Black Rock, Lawrence Co., Arkansas (H. E. Wheeler).
White River, Cotter and Norfolk, Baxter Co., Arkansas (A. A. Hinkley).
Saline River, Benton, Saline Co., Arkansas (H. E. Wheeler).
Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).
Neosho River, near state line, Kansas (R. L. Moodie); Miami, Ottawa Co., Oklahoma (F. B. Isely).

[42] Ten specimens are at hand, but only two or three approach the smooth form, and none is entirely smooth.

[43] An entirely smooth specimen.

[44] In the upper North Fork of the Holston and the upper Clinch River in Virginia, the var. *strigillata* gradually replaces the normal form.

*Distribution and Ecology in Pennsylvania* (See fig. 6): This species has been found both in the larger rivers and in some of the smaller creeks, but according to my experience, it is distinctly more frequent in the latter. Yet it does not go up into the extreme headwaters. It is not rare in the Beaver-drainage, and also in French Creek, but entirely absent in the upper Allegheny. At all other localities, it is distinctly a rare shell, and the same is true for the Ohio below our state.

Whenever I found this species alive, it was in swiftly running water, upon bars of gravel, very often in riffles with an abundant growth of *Dianthera americana*. In fact, on the edge of such patches, I was most successful in taking this species alive. It is mostly not deeply buried, often simply lying upon the bottom. In the Ohio, it is upon the shell-banks, which become accessible only at the lowest stage of the river. This agrees with Scammon (1906), who observed that the "favorite habitat is bars of gravel or shingle in rather swift current."

*General distribution: Type locality*, Wabash River (Say).

Simpson (1900) gives for this species: "Entire Ohio, Cumberland, and Tennessee river systems; west to Nebraska (doubtful); south to Arkansas and Indian Territory." The first three rivers undoubtedly are the metropolis of this species, and here it is found from western Pennsylvania[45] through Ohio and West Virginia to Tennessee and northern Alabama (Tennessee-drainage). It is also frequent in the part of Indiana drained by the Ohio, White, Wabash,[46] and Kankakee Rivers (Call, 1896*a* and 1900), but in Illinois it is found only in the southern part (Ohio and Wabash, Baker, 1906). Thence, in a northerly and northwesterly direction, it is not found any more (this fact should be noted), but it is present farther South in the Mississippi-drainage, in southern Missouri (Utterback, 1916), in southeastern Kansas, eastern Oklahoma, and in Arkansas. Call (1895, p. 15) reports this species from the Alabama River, Selma, Dallas Co., Alabama. This is the only locality outside the Mississippi area, and seems to be erroneous, for it has never been found again in this system.

## Genus Rotundaria Rafinesque (1820).

Ortmann, 1912, p. 257; Simpson, 1914, p. 903 (as subgenus of *Quadrula*).

Type *Obliquaria tuberculata* Rafinesque.

Two species have been assigned to this genus, which may be only varieties of the same species. Only one of them is found in Pennsylvania.

[45] Call (1895) quotes western New York, but this record has never been substantiated. It is missing in Marshall's list (1895).

[46] According to Goodrich (1914), *Q. cylindrica* recently has crossed over into the Maumee River, and descended as far as Antwerp, Paulding Co., Ohio. He calls it by the varietal name *strigillata*, but probably this is an error.

ROTUNDARIA TUBERCULATA (Rafinesque) (1820).

*Quadrula (Rotundaria) tuberculata* (RAFINESQUE) SIMPSON, 1914, p. 903.

Plate V, fig. 4.

*Records from Pennsylvania:*

Marshall, 1895 (Allegheny River, Warren Co.).
Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co.; Beaver River, Wampum, Lawrence Co.).
Ortmann, 1909*b*, p. 201.

*Characters of the shell:* Shell rather large and heavy. Outline subrotund, or ovate, or subquadrate, subtruncate, and sometimes slightly emarginate behind, not very oblique, height and length not very different. Beaks moderately prominent, inclined forward. Beak-sculpture consisting of numerous, fine, irregular, broken, or wavy ridges, showing more or less distinctly a zig-zag arrangement, with a posterior triangular loop most distinct, while anteriorly this arrangement is irregular. The first two or three bars are concentric, then follow three or four which are only double-looped, and then other bars (even as many as ten or more), which exhibit the iregular zig-zag sculpture. The beak-sculpture is continued well upon the disc, and is immediately followed by the nodules of the latter. Shell rather compressed, or only slightly swollen, disk gently convex, with an indistinct, posterior ridge, which may be altogether absent. Posterior slope flat or somewhat depressed, often with a more or less distinct wing-like expansion and elevated posterior upper margin (chiefly in young specimens). Surface of shell covered with tubercles or nodules, which, however, always leave free the anterior portion (one-fourth to almost one-half) of the shell. Tubercles very variable in number, size, arrangement, and shape; they may be rather few, or quite numerous, are always quite irregular in size, and show no definite arrangement. Generally they are a little transverse, at least some of them. In the center of the shell the tubercles are generally most numerous, and upon the posterior slope and the wing, they often assume the shape of radiating, nodulous ribs. In old shells the tubercles disappear toward the lower margin, and in very large specimens the whole lower half of the shell (or even more) may be without tubercles.

Epidermis brown, lighter or darker, uniform in color, only in very rare cases mere traces of broad greenish rays are barely indicated. Growth-rests slightly darker, or not marked.

Hinge-teeth strongly developed and very heavy. Pseudocardinals large, ragged, divergent. Very often there are one or even two subsidiary pseudocardinals in the right valve (one in front, the other behind the normal tooth).

Interdentum well-developed and extremely wide. Lateral teeth short and strong. Beak-cavity very deep, compressed. Dorsal muscle-scars on the hinge-plate. Nacre of a peculiar and characteristic brownish purple color, lighter or darker, sometimes shading to whitish toward the beak-cavity, and coppery-brownish, iridescent posteriorly.

Sexes absolutely indistinguishable in the shell.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Godfrey, Cat. No. 61.4411 | 108 mm. | 96 mm. | 47 mm. |
| 2. Neville Island, Cat. No. 61.1637 | 77 " | 73 " | 41 " |
| 3. Utica, Cat. No. 61.3947 | 58 " | 55 " | 36 " |

*Soft parts* (See Ortmann, 1912, p. 258, fig. 7). Gravid females have been found subsequently. Only the outer gills are charged, the placentæ are subcylindrical and white. *Glochidia* described and figured by Utterback (1916, Pl. I, fig. 4). They are unusually large, 0.267 × 0.325 mm. Surber (1912, Pl. 2, fig. 19) figures the glochidia of the closely allied *R. granifera* (Lea). These also are remarkable for their size, 0.29 × 0.355 mm., but I have found them in *R. granifera* from Black River, Arkansas, to be considerably smaller, 0.25 × 0.28 mm.

*Breeding season:* I found my gravid females on May 22, 1914; May 25, 1915; July 5, 1913; July 7, 1913; July 13, 1913. Utterback's glochidia were found on August 11.

*Remarks:* Although this species resembles in shape and sculpture several other species, chiefly *Quadrula pustulosa* and *Plethobasus cooperianus*, it is always easily recognized by the peculiar color of the nacre and the extremely broad interdentum. I have old specimens, which are so much corroded at the beaks, that the whole section bearing tubercles is gone, and only the smooth lower half of the shell remains intact, yet the interior of the shell characterizes them. All Pennsylvanian specimens are rather flat, but farther down the Ohio occasional specimens are met with which are somewhat more swollen. A specimen from Portsmouth, Ohio, has distinctly more prominent and more incurved beaks, and might fall under *R. granifera* (Lea): but the other characters of the latter, as given by Simpson (1900, p. 795, footnote 2) are absent.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Ohio River, Cooks Ferry and Industry, Beaver Co.; Neville Island, Allegheny Co.
Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Slipperyrock Creek, Wurtemberg, Lawrence Co.
Allegheny River, Godfrey, Johnetta, and Kelly, Armstrong Co.; Walnut Bend, Venango Co.
French Creek, Utica, Venango Co.
Dunkard Creek, Wiley, Greene Co.
Cheat River, Cheat Haven, Fayette Co.

*Localities in Pennsylvania, represented in the Philadelphia Academy of Natural Sciences:*

Ohio River, Beaver, Beaver Co.; Coraopolis, Allegheny Co. (S. N. Rhoads).

*Other localities represented in the Carnegie Museum:*

*Lake-drainage:*

Lake Erie, La Plaisanee Bay, Monroe Co., Michigan (C. Goodrieh).

*Ohio-drainage:*

Ohio River, St. Marys, Pleasants Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.

West Fork River, Lyneh Mines, Harrison Co., West Virginia.

Little Kanawha River, Grantsville, Calhoun Co., West Virginia (W. F. Graham).

Elk River, Shelton, Clay Co., West Virginia.

New River, Hinton, Summers Co., West Virginia.

*Tennessee-drainage:*

Tennessee River, Tuseumbia, Colbert Co., and Florence, Lauderdale Co., Alabama (H. H. Smith).

Shoals Creek, Lauderdale Co., Alabama (H. H. Smith).

Flint River, Gurley, Madison Co., Alabama (H. E. Wheeler).

Paint Rock River, Paint Rock, Jaekson Co., Alabama (H. H. Smith).

Tennessee River, Coneord and Knoxville, Knox Co., Tennessee.

Freneh Broad River, Boyd Creek, Sevier Co., Tennessee.

Noliehueky River, Chunns Shoals, Hamblen Co., Tennessee.

Holston River, McMillan and Maseot, Knox Co.; Hodges, Jefferson Co.; Turley Mill and Noeton, Grainger Co.; Austin Mill and Chureh Hill, Hawkins Co., Tennessee.

South Fork Holston River, Paetolus, Sullivan Co., Tennessee.

North Fork Holston, Rotherwood, Hawkins Co., Tennessee; Hilton, Seott Co., Virginia; Mendota, Washington Co., Virginia.

Clineh River, Solway, Knox Co.; Edgemoor, Clinton, and Offutt, Anderson Co.; Clineh River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Speers Ferry, Seott Co., Virginia.

*West of the Mississippi:*

James River, Galena, Stone Co., Missouri (A. A. Hinkley).

White River, Hollister, Taney Co., Missouri (W. I. Utterbaek); Rogers, Benton Co., Arkansas (R. L. Moodie); Cotter, Baxter Co., Arkansas (A. A. Hinkley).

*Distribution and Ecology in Pennsylvania* (See fig. 7): In Pennsylvania, this species has a rather wide distribution, being found in all three river-systems. It goes rather high up (in the Allegheny as far up as Warren Co., according to Marshall, 1895). The smallest streams in which I have found it are Slipperyrock, French, and Dunkard Creeks. From the Monongahela proper records are missing, but it ascends to West Virginia (West Fork River). It is nowhere abundant, and is decidedly one of the rarer shells, only few individuals having been found at any one place. This also holds good for the Ohio below Pittsburgh, where this species is by no means abundant.

It is hard to say what the ecological preferences are, but the specimens I collected alive always came from riffles with rather coarse gravel and a rapid flow of water. In the Ohio proper it inhabits the shell-banks. However, Baker (1898*a*, p. 36) says that it is found in the Chicago area in the larger lakes and rivers on a muddy bottom.

*General distribution: Type locality,* Ohio River (Rafinesque).

The range of this species according to Simpson (1900), is "Mississippi-drainage generally; southern Michigan; San Saba Co., central Texas." Call (1885) says: "New River, Virginia, to Tuscumbia, Alabama; to Iowa; to Michigan."

The area occupied by this species includes the Tennessee, Cumberland, and Ohio drainages; toward the west and southwest, it apparently becomes scarce. It has not been reported from Kansas (Scammon, 1906), but is present in southern Missouri and northwestern Arkansas.[47] Simpson's record from Texas is the

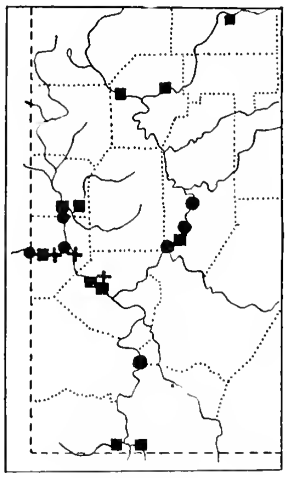

FIG. 7.

■ *Rotundaria tuberculata.*
+ *Plethobasus cooperianus.*
● *Plethobasus cyphyus.*

only one in this state, and the list of Singley (1893) does not contain it. Also in a northwesterly direction, the distribution seems to be limited, and barely reaches to Iowa in the Mississippi. Northwards it extends all over Illinois, to southern Cook Co. (Baker, 1898*a*, 1906) and goes in the Mississippi, Rock, Wisconsin, and St. Croix Rivers, to Wisconsin (Barnes, 1823; Lapham, 1860; Cooper, 1855). In Indiana it has been recorded by Call (1896*a*) from the Ohio, Wabash, and White

[47] Call (1895) does not mention this species from Arkansas, but, aside from the localities represented in the Carnegie Museum, it occurs also in the Big Buffalo Fork of White River (Meek & Clark, 1912) and W. I. Utterback (1916) reports it from southern Missouri.

Rivers, and in Ohio by Sterki (1907*a*) from the Ohio, Little Miami, and Tuscarawas Rivers. In addition, it is found in southern Michigan (Walker, 1898), and in Lake Erie (Barnes, 1823; Walker, 1913). Here we have apparently the only region, where this species leaves the Mississippi-drainage, and it is quite clear, that this was done by the Wabash-Maumee route. On the Pennsylvanian shores of Lake Erie it has not as yet been found.

### Genus PLETHOBASUS Simpson (1900).

Ortmann, 1912, p. 259; Simpson, 1914, p. 805 (as section of *Pleurobema*).

Type *Obliquaria cyphya* Rafinesque.

Three species are known to belong to this genus, of which only two are found in Pennsylvania. But since the third turns up in the Ohio, not far from the western state-line, I give here a key for all three of them.

#### KEY TO THE SPECIES OF PLETHOBASUS.

$a_1$. Shell rounded, ovate, or oblique, without a radial depression running toward the posterior basal margin.

- $b_1$. Shell subrotund, or subovate, only slightly oblique. Disk with scattered, irregularly disposed, rounded, or slightly transverse nodules, leaving free the anterior part of the shell, but generally extending more or less upon the posterior slope............................*P. cooperianus.*
- $b_2$. Shell subovate, very strongly oblique. Disk with more or less transverse tubercles, or subconcentric, more or less interrupted ridges, restricted to the middle of the shell, leaving the anterior part as well as the posterior slope free of sculpture.....*P. cicatricosus* (extralimital).

$a_2$. Shell obliquely elongated, with a broad and shallow radial depression running toward the post-basal margin. In front of the depression a radiating row of low and broad, often transverse, tubercles; sometimes also a few indistinct tubercles behind the depression............*P. cyphyus.*

*Remarks as to nomenclature and synonymy:* Frierson (1911) has published a paper dealing with these forms, but in my opinion he starts from an incorrect assumption. This assumption is, that *U. cicatricosus* Say (1829) is the same as *U. æsopus* Green (1827) (which in turn is identical with *cyphyus* Rafinesque, 1820). The original description of Say mentions two important characters: tubercles and anterior position of beaks (great obliquity), which do not leave the slightest doubt, that the species was correctly understood by subsequent writers (*U. cicatricosus* Reeve, 1864, Pl. 8, fig. 31, and Simpson, 1900).

Reeve figures (*Cf.* Pl. 13, fig. 50) a smaller and less elongated individual. Frierson believes that this is another species. If that were the case, I would be compelled to make three or four additional species out of my (scanty) material of *cicatricosus.*

There appears to me to be no ground for Frierson's introduction of the new

specific name of *detectus* (*l. c.*, p. 52, Pl. 2, lower fig.; Pl. 3, upper fig.). This is a synonym of *cicatricosus*.

I think that Frierson makes another mistake in identifying Lea's *U. varicosus* (Obs. I, 1834, Pl. 11, fig. 20) with his *detectus*. Lea's species is very doubtful, and the figure is possibly inaccurate in several respects; but chiefly in that the sculpture is entirely different from that of the species of *Plethobasus* (continuous, concentric, rather regular ridges, not confined to the middle of the shell). I have shown above that Lea's species is, if anything, an exceptional individual of *Fusconaia subrotunda* (Lea) (See above, p. 9).

Frierson's *U. cicatricoides* (p. 53, Pl. 2, upper fig.) is also only an extreme variation of *cicatricosus*, distinguished by less oblique shell, and less anterior beaks. It connects this species with *cooperianus*. I have a specimen (St. Marys, West Virginia), which answers well to Frierson's figure. A specimen from the same locality is more distinctly oblique, and stands actually midway between the two figures on Frierson's Pl. 2, and comes very close to Call's figure of *U. varicosus* (1900, Pl. 55) except that it is not so much drawn out at the lower posterior end. And further certain individuals of *P. cooperianus*, collected by myself, very closely approach in outline the first one, just mentioned, but the sculpture is more distinctly and typically that of *cooperianus*.

Finally these intergrading forms also show certain relationships to *P. cyphyus*, which will be discussed below.

### Plethobasus cooperianus (Lea) (1834).

*Quadrula cooperiana* (Lea) Simpson, 1914, p. 852.

Plate V, fig. 5.

*Records from Pennsylvania:*

Rhoads, 1899 (Ohio River, Beaver, Beaver Co.; and Coraopolis, Allegheny Co.).
Ortmann, 1909*b*, p. 198.

*Characters of the shell:* Shell moderately large, heavy. Outline subrotund, subovate, or subtriangular, about as long as high, slightly oblique. Beaks moderately high, more or less inclined forward, but not at the anterior end of the shell. Beak-sculpture not observed, but probably poorly developed, and not extending to any considerable degree upon the disk, since the latter is always smooth near the beaks before the tubercles begin. Shell moderately swollen, rather evenly convex upon the sides, without a posterior ridge. Posterior slope very slightly compressed, in young specimens sometimes with an indication of a wing. Disk covered with nodes or tubercles, which, however, always leave free the anterior

part of the shell, and may be scarce or nearly absent upon the posterior slope. Tubercles variable in size, shape, and arrangement. There is no definite arrangement, except sometimes a concentric one, parallel to the growth-lines. The shape of the tubercles may be rounded or tear-like, but generally there are at least some, which are peculiarly compressed and transversely elongated (appearing as "pinched up"). The transverse dilatation of the tubercles is not very great. The tubercles may be rather crowded and numerous, or they may be scarce, sometimes only a few are developed, and they often disappear entirely toward the lower margin. Posteriorly, upon the posterior slope, the tubercles may be missing, or a few, or they may be as numerous as in the middle of the shell, or may even assume the shape of nodular, radiating ribs.

Epidermis yellowish brown to rusty or chestnut-brown, rather dark, when old. Very often the posterior slope is lighter than the rest, yellowish or olive-brown. Growth-rests darker. Greenish, indistinct rays are very rarely indicated and only in young specimens.

Hinge-teeth well-developed. Pseudocardinals divergent, ragged. Interdentum moderately wide. Lateral teeth moderately long, strong. Beak-cavity moderately deep. Dorsal muscle-scars on the hinge-plate. Nacre whitish, often suffused with a delicate pink inside of the mantle-line, most intense toward the hinge-teeth. Very rarely the whole interior is pink.

No sexual difference whatever in the shells. Call's remarks (1900, p. 485) about the differences of the males and females do not at all hold good.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Industry, Cat. No. 61.3882 | 90 mm. | 78 mm. | 46 mm. |
| 2. Shippingport, Cat. No. 61.3881 | 69 " | 61 " | 38 " |
| 3. St. Marys, Cat. No. 61.4595 | 69 " | 71 " | 41 " |

*Soft parts* (See Ortmann, 1912, p. 361). *Breeding season:* Gravid females and *glochidia* have not yet been observed. On June 20 to 22, 1911, I obtained a good number (about fifty) specimens in the Ohio at St. Marys; additional ones were found on July 13, 1911, at Portland. All had the characteristic light orange color of the soft parts. Of about two dozen females none was gravid, and every one had only the outer gills marsupial. The sexual glands were grayish or brown and in many cases distinctly pinkish. Thus it is probable, that the eggs also are pink, as in *P. cyphyus*.

*Remarks:* Externally in shape and sculpture this species greatly resembles *Quadrula pustulosa* (Lea) and *Rotundaria tuberculata* (Rafinesque). In the tubercles the resemblance to the latter species is so great that there might be a close genetic

relationship between the two. However, in the beak-sculpture, in the hinge, the color of the nacre, and chiefly in the soft parts, there are important differences, amounting to generic distinctness. The color of the soft parts of *P. cooperianus* is also rather unique (pale orange, found also in the other species of the genus). *Q. pustulosa* is, of course, distinguished by the soft parts; but there are also differences in the shell. It is generally smaller, the tubercles are not of the peculiar transverse shape, and the outline of the shell is not so oblique. The color of the epidermis and the presence of broad rays near the beaks also distinguish *Q. pustulosa*.

*P. cooperianus* is very variable in outline. There are specimens, which are almost round, but generally they are drawn out at the lower posterior end, so as to render the outline ovate and oblique, and in some cases even subtriangular. The beaks are always inclined forwards, but they never are at the most anterior end of the shell. Very oblique specimens approach *P. cicatricosus* (Say), and individuals corresponding to *cicatricoides* of Frierson (see above), may be regarded to a certain degree as intergrades between the two. In sculpture this species also intergrades in the direction of *cicatricosus*, if the tubercles are more or less restricted to the middle of the shell. However, although there are certain individuals, which are intermediate in the one or the other character, there is no complete series of intergrades, and all my specimens may be assigned to the one or the other species.

Specimens from the Cumberland and Tennessee drainages have the sculpture generally better developed than specimens from the Ohio River.

*Localities represented in the Carnegie Museum:*

Ohio River, Shippingport, Cooks Ferry, and Industry, Beaver Co., Pennsylvania; Clarington, Monroe Co., Ohio; St. Marys, Pleasants Co., West Virginia; Marietta, Washington Co., Ohio (V. Sterki); Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio.

Cumberland River, Cloyds Landing, Cumberland Co., Kentucky (B. Walker donor).

Tennessee River, Knoxville, and Brabsons Ferry, Knox Co., Tennessee.

Clinch River, Edgemoor, Anderson Co., Tennessee.

*Distribution and Ecology in Pennsylvania* (See fig. 7): This is one of the rarest species in Pennsylvania, and exists only in the Ohio River in Beaver and Allegheny Cos., and is even there very scarce. I was able to secure only four specimens, one of which was alive. The latter was found upon a shell-bank, in a steady current, associated with the usual bank-forming species.

Farther down the Ohio, *P. cooperianus* becomes more abundant, and it is quite common in the region of St. Marys and Marietta, where it is frequently taken

by the clam-diggers out of deep water, with the other bank-forms. This seems to be its favorite habitat.

*General distribution: Type-locality*, Ohio River (Lea).

This species seems to be restricted to the Ohio, Cumberland, and Tennessee systems, and the known records are all from these rivers and some of their larger tributaries, as for instance the Clinch in eastern Tennessee, the Wabash in Illinois and Indiana, and possibly also the Illinois River (Fulton Co.) in Illinois (Baker, 1906). It has been reported also from the Mississippi in Iowa,[48] but this is doubted by Simpson. It is to be especially noted, that from Indiana through Ohio and West Virginia to Pennsylvania, this species is restricted to the Ohio proper.

### PLETHOBASUS CYPHYUS (Rafinesque) (1820).

*Pleurobema æsopus* (GREEN) SIMPSON, 1914, p. 806; *Pleurobema cyphia* (RAFINESQUE) VANATTA, 1915, p. 556.

Plate V, fig. 6; Plate VI, figs. 1, 2, 3.

*Records from Pennsylvania:*

Green, 1827 (rivers near Pittsburgh).
Harn, 1891 (western Pennsylvania).
Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co.; and Beaver River, Wampum, Lawrence Co.).
Ortmann, 1909*b*, p. 198.

*Characters of shell:* Shell rather large, heavy. Outline elongated-subovate, generally (except in young shells) distinctly longer than high, somewhat oblique, with the beaks not very high, inclined forward, but not at the anterior end of the shell. Beak-sculpture consisting of a few, thick, concentric ridges, not extending upon the disk. Shell moderately swollen, but old shells sometimes more considerably so; sides convex, with a broad and shallow radial depression, running from the beaks toward the posterior lower margin, producing a more or less distinct shallow excavation of the margin. In front of this depression, a radial row of low, transverse tubercles running from the beaks to the lower margin. These tubercles begin at a certain distance from the beaks, are more or less distinct (sometimes almost obsolete), and are somewhat irregular, larger or smaller. In rare cases they are cut by obscure, nearly vertical, lines (similar to *P. cicatricosus*). Behind the radial depression there is a low and broad ridge, passing gradually into the posterior slope. This part of the shell is generally less swollen than the anterior, and may be entirely smooth, or may show irregular, low rugosities, and sometimes

[48] Call (1885) and Keyes (1888) give Muscatine, Iowa, and Pratt (1876) Davenport, Iowa, but it is not in Witter's (1878) list from Muscatine.

there are individuals with indications of another row of tubercles upon the posterior ridge, which is, however, always less distinct than the anterior row.

Epidermis yellow to dark brown. In young specimens, the color is generally a rather light yellow (wax-yellow), becoming russet or chestnut-brown in older ones. There is no trace of rays. Growth-rests darker than the rest of the surface, but not sharply marked.

Hinge-teeth well-developed. Pseudocardinals moderately large, divergent, ragged. Interdentum moderately wide or narrow. Lateral teeth rather long. Beak-cavity not very deep. Dorsal muscle-scars on the hinge-plate close to the beak-cavity. Nacre white.

There is not the slightest sexual difference in the shell, and neither the length nor the obesity is connected with the sex.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Kelly, Cat. No. 61.3817 | 122 mm. | 81 mm. | 50 mm. |
| 2. Kelly, Cat. No. 61.4598 (long ♂) | 108 " | 74 " | 47 " |
| 3. Kelly, Cat. No. 61.5566 (long ♀, gravid) | 93 " | 64 " | 43 " |
| 4. Kelly, Cat. No. 61.3817 (short ♀, gravid) | 90 " | 67 " | 42 " |
| 5. Godfrey, Cat. No. 61.4599 (short ♂) | 88 " | 72 " | 45 " |
| 6. Shippingport, Cat. No. 61.4600 (long ♂) | 78 " | 58 " | 36 " |

*Soft parts* (See Ortmann, 1912, p. 260, fig. 8). *Glochidia* (See Ortmann, *ibid.*). It should be remarked that the measurements previously given were taken from immature glochidia. Gravid females collected subsequently contained fully developel larvæ, and according to these, the glochidia measure 0.21 × 0.20 mm. Surber (1912, Pl. 1, fig. 12) illustrates them, and gives the size as 0.22 × 0.20 mm.

*Breeding season:* I have found gravid females on the following dates: June 20, 1911; June 21, 1911; June 22, 1909; July 3, 1908; July 4, 1911; July 13, 1908; July 13, 1911; July 25, 1910; July 27, 1910. Glochidia were observed on July 4 and July 25. Thus this species appears to be typically tachytictic, breeding in June and July. Probably the season begins in May, as stated by Surber.

*Remarks:* This is a well-marked species, at least in Pennsylvania, characterized by the shape of the shell, sculpture, and color of the epidermis and soft parts. The most closely allied species is *P. cicatricosus*, a form not found in Pennsylvania, but farther down the Ohio (nearest point St. Marys, West Virginia). *P. cyphyus* is distinguished from this species by the more elongated, less oblique shape, with the beaks less anterior, by the sculpture, and the presence of an oblique furrow upon the disk. However, there are individuals, which form, to a degree, a transition between these two species. To these transitional forms belongs *U. cicatricoides* of Frierson (See above, p. 62), but, on account of the absence of a radiating furrow,

the latter should be classed rather with *P. cicatricosus*. One of my specimens from St. Marys agrees rather well with *U. cicatricoides*, but it has upon the disk a slight indication of a depression, since the tubercles are cut off rather suddenly behind, making the posterior part of the shell appear contracted; but the broad furrow of *P. cyphyus* is not by any means developed.

In sculpture, *P. cyphyus* represents a further reduction of the tubercles of *P. cicatricosus*. They are rather poorly developed, but still show in most cases the character of short, transverse ridges. Sometimes these tubercles have almost entirely disappeared. Where they are better developed, in rare cases even the vertical dividing lines of the ridges, seen so frequently in *P. cicatricosus*, are indicated.

Young specimens of *P. cyphyus* somewhat resemble in shape *Truncilla rangiana* (Lea). But the latter species has a more greenish olive epidermis, with more or less distinct rays.

There is considerable variation in the comparative length of the shell of *P. cyphyus*. A short appearance is given to the shell by a smaller development of the posterior slope, and such shells are decidedly more abundant among young individuals. Old specimens are, as a rule, greatly elongated, and in these it often happens that the radial furrow becomes effaced. If such specimens have at the same time poorly developed tubercles, they resemble in shape old specimens of *Fusconaia subrotunda*, but they generally differ in the color of the epidermis, lighter hinge, and chiefly in the color of the soft parts (light orange). Of course, if females are at hand, no mistake is possible.

*Localities in Pennsylvania, represented in the Carnegie Museum:*

Ohio River, Shippingport and Industry, Beaver Co.; Coraopolis, Allegheny Co. (S. N. Rhoads).
Monongahela River, Westmoreland Co. (G. A. Ehrmann).
Allegheny River, Aladdin, Godfrey, Kelly, and Templeton, Armstrong Co.

*Locality in Pennsylvania represented in the Philadelphia Academy of Natural Sciences:*

Beaver River, Wampum, Lawrence Co. (S. N. Rhoads).

*Other localities represented in the Carnegie Museum:*

*Ohio-drainage:*

Ohio River, Toronto, Jefferson Co., Ohio; St. Marys, Pleasants Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.
Tuscarawas River, Ohio (Holland collection).
Wabash River, New Harmony, Posey Co., Indiana (A. A. Hinkley).

*Tennessee-drainage:*

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).

French Broad River, Boyd Creek, Sevier Co., Tennessee.

Holston River, McMillan and Mascot, Knox Co.; Hodges, Jefferson Co.; Holston Station, Grainger Co., Tennessee.

North Fork Holston River, Rotherwood, Hawkins Co., Tennessee.

Clinch River, Solway, Knox Co.; Edgemoor, Clinton, and Offutt, Anderson Co.; Black Fox Ford, Union Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Clinchport, Scott Co., Virginia.

Powell River, Combs, Claiborne Co., Tennessee.

*West of Mississippi:*

Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).

*Distribution and Ecology in Pennsylvania* (See fig. 7): This species is found in Pennsylvania, preëminently in the Ohio and Allegheny Rivers; from the localities in the Monongahela and Beaver, only single individuals are known. It prefers riffles with coarse gravel and strong current, and in Beaver Co. it is found upon the shell-banks in a strong and steady current. The same is true farther down the Ohio, where it is often obtained by the clam-diggers.

*General distribution: Type locality,* Falls of the Ohio (Rafinesque) at Louisville, Kentucky.

In the Allegheny River, at Templeton, Armstrong Co., and in the Monongahela, in Washington and Westmoreland Cos., Pennsylvania, this species reaches its highest points of advance in an upstream direction. Also Beaver River at Wampum, Lawrence Co., is an extreme point. Farther westward, its range follows the Ohio, and embraces, according to Simpson (1900), the Ohio, Cumberland, and Tennessee river-systems; west to Missouri and Minnesota. In the upper Ohio, it goes very little into the tributaries, and is known only from the Tuscarawas and Scioto in Ohio (Sterki, 1907*a*[49]), Wabash (Call, 1896*a* and 1900), and White River (Lea, Obs. X, 1863, p. 432) in Indiana. In Illinois it covers a large territory (Illinois River up to Kankakee and Fox Rivers). It also follows up the Mississippi and its tributaries in northern Illinois and eastern Iowa (Des Moines River, Witter, 1878, Call, 1885), and goes as far as Minnesota (Grant, 1886, and Holzinger, 1888).

West of the Mississippi, records are scarce or doubtful,[50] but the Carnegie Museum has it from the Meramec River, near St. Louis, and Utterback (1916)

[49] Sterki gives also the Mahoning River. I question this record, since I have never seen a trace of it in the lower Mahoning in Pennsylvania, and since Dean (1890) does not mention it.

[50] Scammon gives it as rare from Verdigris River in Kansas. A specimen from Wakarusa River, Lawrence, Douglas Co., Kansas, determined by Scammon as *P. æsopus*, and sent to the Carnegie Museum by R. L. Moodie, agrees very well with Scammon's figure (1908, pl. 78, fig. 2) but it is not this species. Our specimen is an old, dead shell, and probably an abnormal *Quadrula quadrula*.

mentions at least one place in western Missouri (Little Blue River, Courtney, Jackson Co., near Kansas City). The species has never been reported from the region of the lower Mississippi, and although Call (1896*a* and 1900) includes the Alabama River in its range, this record has not been confirmed by anybody else (See Lewis, 1877).

## Genus Pleurobema Rafinesque (1820).

Ortmann, 1912, p. 261; Simpson, 1914, p. 732.

Type *Unio clava* Lamarck.

The conception of this genus has been changed greatly in recent times. In Pennsylvania, I distinguish two species, but one of them is quite polymorphous, with a number (five) of variations and ecological (or local) races or varieties.

### Key to the Species and Varieties of Pleurobema.

$a_1$. Shell rather large, upright, or oblique. Epidermis chestnut to dark brown or blackish, with indistinct capillary rays, which generally are not broken up into blotches.

- $b_1$. Shell not very oblique, more or less upright. Nacre white or red. Radial furrow strong, weak, or absent. Diameter variable.
  - $c_1$. Furrow strong or weak, but always present. Nacre white, very rarely red. Diameter mostly over fifty percent of length (very rarely less). Shape upright.
    - $d_1$. Outline subtriangular; furrow strong. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *P. obliquum.*
    - $d_2$. Outline rounded; furrow generally weak, but present. . . . . . . . . . *P. obliquum cordatum.*
  - $c_2$. Furrow generally absent (rarely a trace seen). Nacre white or red. Diameter variable. Shape subtriangular, upright, or slightly oblique.
    - $d_1$. Shell rather large. Growth lines irregular and indistinct. Epidermis dark.
      - $e_1$. Nacre white, rarely red. Diameter fifty percent of length or more. *P. obliquum catillus.*
      - $e_2$. Nacre white, salmon, or red. Diameter less than fifty percent of length. *P. obliquum coccineum.*
    - $d_2$. Shell smaller. Growth lines more distinct and regular. Epidermis lighter. *P. obliquum pauperculum.*
- $b_2$. Shell very oblique, beaks directed anteriorly. Nacre generally red, rarely white. Furrow strong, rarely weak. Diameter mostly over fifty percent of length. . . . . . . . . . . . . *P. obliquum rubrum.*

$a_2$. Shell rather small, very oblique, beaks located well anteriorly. Epidermis yellowish or light brown, with distinct rays, which are often broken up into blotches. . . . . . . . . . . . . . . . . . . . . . . . . . . *P. clava.*

## Pleurobema obliquum (Lamarck) (1819).

*Quadrula obliqua* (Lamarck) Simpson, 1914, p. 881.

Plate VI, figs. 4, 5, 8.

*Records from Pennsylvania:*

Call, 1885 (Allegheny River).
Harn, 1891 (western Pennsylvania).

Clapp, 1895 (Allegheny Co.).
Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co.).[51]
Ortmann, 1909*b*, p. 199.

*Characters of the shell:* Shell rather large, heavy. Outline subtriangular, rounded before, subangular and more or less drawn out at the lower posterior end, with the lower margin gently convex in the anterior part, and generally concave in the posterior part, and with the supero-posterior margin gently curved. Beak more or less elevated, and swollen, directed obliquely forward, or more or less incurved, situated nearer to the anterior end of the shell. Beak-sculpture rudimentary, consisting of two or three indistinct, concentric bars. Shell rather swollen anteriorly, the diameter generally over fifty percent of the length. Posteriorly the shell is compressed, with a broad, more or less distinct, radial furrow, running from the beaks toward the lower posterior margin, producing there a shallow emargination. Surface of shell smooth, without any sculpture. Behind the radial depression there is a rounded, low elevation, which, however, does not form a distinct ridge, and passes insensibly into the posterior slope.

Epidermis lighter or darker brown, generally of a dark chestnut hue, blackish, when old, with fine and indistinct green or blackish capillary rays, or bundles of rays, which are mostly entirely obliterated in old specimens. The rays do not break up into blotches. Growth-rests more or less distinct, darker than the rest of the shell.

Hinge-teeth well-developed, rather strong. Pseudocardinals divergent, ragged. Interdentum rather wide. Lateral teeth moderately long. Beak-cavity more or less deep, often somewhat compressed. Dorsal muscle-scars on the hinge-plate. Nacre mostly white, rarely reddish.

No sexual differences in the shell.

| | L. | H. | D. | Pr.ct. |
|---|---|---|---|---|
| *Size:* 1. Industry, Cat. No. 61.3900 (unusually produced) | 109 mm. | 82 mm. | 46 mm. | .42 |
| 2. Industry, Cat. No. 61.3902 | 90 " | 77 " | 51 " | .57 |
| 3. Godfrey, Cat. No. 61.3901*a* | 83 " | 69 " | 42 " | .51 |
| 4. Charleroi, Cat. No. 61.2869 | 59 " | 52 " | 33 " | .56 |

*Soft parts* (See Ortmann, 1912, p. 264). I have examined nearly a thousand individuals of this species, and have found the structure of the soft parts as described, with only the outer gills marsupial. However, a few exceptions have been noted in the case of five specimens received through the courtesy of Dr. R.

[51] As has been stated by the writer (1909*b*, pp. 186 and 199) only part of the specimens from Coraopolis, recorded by Rhoads, belong to *Pl. obliquum*, the rest are *Fusconaia subrotunda*, while all of Rhoads' specimens from Beaver (in the Philadelphia Academy) are *F. subrotunda*.

E. Coker, by whom they were collected in the Cumberland River, near Clarksville, Montgomery Co., Tennessee. In the extreme case about half of the inner gills, in their middle portion near the margins, was marsupial; in three other cases, much smaller sections of the inner gills were charged, and in one case a few eggs were near the central margin of the right inner gill. Along with these abnormal specimens, two were received with normal marsupium, but none had all four gills *fully* charged, as is the case in the genera *Fusconaia*, *Quadrula* etc.[52] It should be borne in mind that these specimens were selected and sent to me to demonstrate the fact that sometimes there are eggs in the inner gills. This observation does not invalidate the rule that this species *normally* has only the outer gills marsupial. Since the genus *Pleurobema* undoubtedly is descended from ancestral forms, which had all four gills marsupial (as for instance *Fusconaia*), it is not astonishing, that the present species sometimes reverts, although not fully, to this old condition (*Atavism*). From the genus *Fusconaia*, to which it is most closely allied by the shell, it differs nevertheless by the fact that the placentæ are always lanceolate, not subcylindrical, and that their color is always white, never red.

*Glochidia* (observed by myself only in the specimens just mentioned) agreeing in shape and size with those of *P. obliquum coccineum:* 0.15 × 0.15 mm. According to Surber (1915) they measure: 0.160 × 0.175 mm.

*Breeding season:* I have gravid females collected on the following dates: June 3, 1911; June 20, 1911; June 21, 1911; June 24, 1909. On the first date a specimen with glochidia was obtained. The species is apparently tachytictic, but the duration of the breeding season is not fully known. Surber's specimens with glochidia were collected on July 14.

*Remarks:* A quite characteristic species, in its typical phase (called "pigtoe" by the clam-diggers), but subject to an immense range of variation. The variations concern chiefly the general shape. While the typical form (See Pl. VI, fig. 4) is characterized by its subtriangular outline, by the rather upright shape, with the gently incurved beaks not situated at the anterior end, and by the well-developed radial furrow, all these characters may vary. The commonest variation is that in which the posterior lower angle becomes more or less produced, chiefly occurring in old shells (Pl. VI, fig. 8) so that the diameter becomes unusually low. It is, however, observable that such specimens, when young, were quite normal. In other specimens the beaks are more upright, making the whole shell appear higher and shorter. The radial depression is extremely variable, often different on the two sides of the same specimen, and tends in many specimens to

[52] Lefevre & Curtis (1912, p. 120) enumerate this species under the "Tetragenæ," where the marsupium comprises all four gills.

become effaced, leading thus to the var. *catillus* (Pl. VI, figs. 5, 6). Again the posterior angle of the shell may be less developed, and the posterior end may be shorter, a condition generally connected with a deficient development of the whole posterior slope, thus emphasizing the swollen anterior part of the shell. In such cases, the lower margin is more curved upward behind, producing a more rounded, not triangular outline, leading to the var. *cordatum*. The obesity of the shell, although always considerable, is variable, but there are no shells which could be called flat; yet in specimens with the posterior angle much drawn out, the posterior section of the shell may be flat (Pl. VI, fig. 8). The nacre is generally white, but individuals are occasionally found, where it is reddish.

Although the group of *P. obliquum* has been misunderstood by most authors, the main species has generally been properly recognized, and the references given by Simpson are correct. But the figure of Call (1900, Pl. 59, upp. fig.), under the name of *U. solidus*, should be added: it is a typical *P. obliquum*.

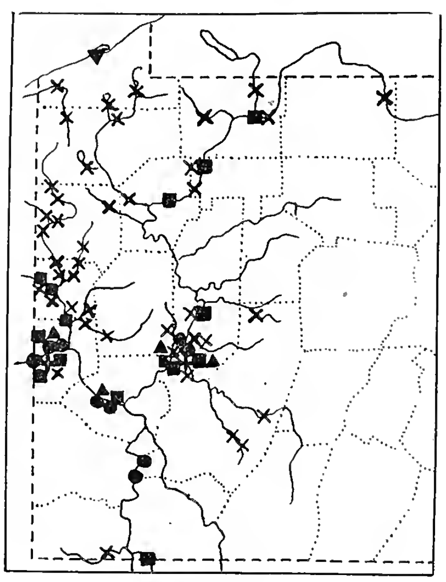

FIG. 8.

● *Pleurobema obliquum.*
+ *Pleurobema obliquum cordatum.*
■ *Pleurobema obliquum catillus.*
× *Pleurobema obliquum coccineum.*
▼ *Pleurobema obliquum pauperculum.*
▲ *Pleurobema obliquum rubrum.*

*Localities in Pennsylvania represented in the Carnegie Museum:*

Ohio River, Smiths Ferry (W. F. Graham), Shippingport, Cooks Ferry and Industry, Beaver Co.; Coraopolis (S. N. Rhoads) and Neville Island, Allegheny Co.

Monongahela River, Westmoreland Co., and Charleroi, Washington Co. (G. A. Ehrmann).

Allegheny River, Godfrey and Kelly, Armstrong Co.

*Other localities represented in the Carnegie Museum:*

*Ohio-drainage:*

Ohio River, Beech Bottom, Brooke Co., West Virginia (W. F. Graham); Toronto, Jefferson Co., Ohio; Clarington, Monroe Co., Ohio; St. Marys, Pleasants Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.

Tuscarawas River, Ohio (Holland collection).

*Cumberland-Tennessee-drainage:*

Cumberland River, Clarksville, Montgomery Co., Tennessee (R. E. Coker donor).

Tennessee River, Tuscumbia, Colbert Co., and Florence, Lauderdale Co., Alabama (H. H. Smith).

Paint Rock River, Paint Rock, Jackson Co., Alabama (H. H. Smith).

Tennessee River, Knoxville and Brabsons Ferry, Knox Co., Tennessee.

French Broad River, Boyd Creek, Sevier Co., Tennessee.

Holston River, Mascot, Knox Co.; Hodges, Jefferson Co.; Noeton and Holston Station, Grainger Co., Tennessee.

Clinch River, Solway, Knox Co.; Edgemoor, Clinton, and Offutt, Anderson Co., Tennessee; Needham Ford, Union Co., Tennessee (B. Walker donor).

*Distribution and Ecology in Pennsylvania* (See fig. 8): The typical form of *P. obliquum* is restricted in Pennsylvania to the three large rivers, the Ohio, Allegheny, and Monongahela. In the Allegheny it is found as high up as Armstrong Co., but is not very abundant there. In the Monongahela, judging from the large number of specimens collected by G. A. Ehrmann, it must have been at one time abundant in the vicinity of Charleroi, but we do not know how far it ascended the river. In the Ohio below Pittsburgh it is a common shell. Farther down, it is extremely abundant, and is the prevailing species, at least locally. It is the shell, which largely contributes in forming the shell-banks, in rather deep, steadily flowing water, and, next to the "mucket" (*Actinonaias ligamentina*), it is the shell most highly valued by the clam-diggers. In Pennsylvania, it is present also in riffles, and immediately above them, in strong current, and among coarse gravel.

*General distribution: Type locality,* Ohio River (Lamarck).

On account of the great confusion prevailing with regard to this species, it is hard to make out the limits of its distribution, but it is certain that it chiefly inhabits the systems of the Ohio, Cumberland, and Tennessee Rivers. In the Ohio-drainage it does not go much into the tributaries, but is known from the Muskingum-Tuscarawas River in Ohio (Sterki, 1907*a*), and from the Wabash in Indiana (Call, 1896*a* and 1900). It occurs also in the Mississippi in Illinois (Baker, 1906), and goes northward into Wisconsin and Minnesota. It also has been reported from the Alabama River (Lewis, 1877, and Simpson, 1900), but this is doubtful. I have not seen any specimens of it in the collections made there by H. H. Smith.

The existence of typical *P. obliquum* becomes uncertain in the west and southwest. It has not been recorded by Scammon (1906) from Kansas, and although Call (1895, p. 32) cites it from the Ouachita River in Arkansas, I have never seen a genuine *P. obliquum* in all the rich material I have received from H. E. Wheeler taken from this river. In this region it seems to be entirely replaced by the vars. *catillus* and *rubrum*. Utterback (1916) failed to find this species in Missouri.

From what we know at present it is quite evident that the species prefers the larger rivers (See Call, 1900, p. 502) and thus it is easily understood why it has not migrated from the Mississippi-Ohio system into any other drainage.

### PLEUROBEMA OBLIQUUM CORDATUM (Rafinesque) (1820).

*Quadrula plena* (LEA) SIMPSON, 1914, p. 886; *Quadrula cordata* (RAFINESQUE) VANATTA, 1915, p. 558.

Plate VII, fig. 1.

No records from Pennsylvania previous to those given below.

*Characters of variety:* Much like typical *obliquum*, but shape more rounded, which is due to the slight development of the lower posterior angle and the whole posterior slope. In consequence of this, the shell appears more elevated and more upright. With regard to the diameter, the shell resembles *P. obliquum* (over fifty percent of length). The radial furrow is generally weak, but present. Nacre white, or slightly pink.

| | L. | H. | D. | Pr.ct. |
|---|---|---|---|---|
| *Size:* 1. Cooks Ferry, Cat. No. 61.4434*b* | 78 mm. | 79 mm. | 51.5 mm. | .66 |
| 2. Godfrey, Cat. No. 61.3901*b* | 70 " | 67 " | 43 " | .61 |
| 3. Godfrey, Cat. No. 61.4378 | 56 " | 57 " | 34 " | .61 |

*Soft parts* and *glochidia* not observed in Pennsylvania. In the region of the upper Tennessee I found a few gravid females, but none with glochidia. The anatomy is the same as in the main species. Only the outer gills possess marsupial structure.

*Breeding season:* Gravid females were found on May 25, 1914.

*Remarks:* This form hardly deserves a varietal name, and I retain it only because it has been distinguished as a "species" by previous authors. In Pennsylvania, it is nothing but an individual variation, found very rarely, and always associated and intergrading with the typical form. The three specimens, of which measurements are given, are the only ones I have from Pennsylvania, and even these are not quite typical representatives of *cordatum*. In the upper Tennessee region, I have found this form more frequently, but also there it is by no means a well-defined race, and I know of no region, where *cordatum* is found pure.

*Localities represented in the Carnegie Museum:*

*Ohio-drainage:*

Allegheny River, Godfrey, Armstrong Co., Pennsylvania.

Ohio River, Cooks Ferry, Beaver Co., Pennsylvania.

*Tennessee-drainage:*

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith); Bridgeport, Jackson Co., Alabama (B. Walker, donor).

French Broad River, Boyd Creek, Sevier Co., Tennessee.

Holston River, Mascot, Knox Co.; Hodges, Jefferson Co.; Holston Station, Grainger Co., Tennessee.

Clinch River, Solway, Knox Co.; Edgemoor and Clinton, Anderson Co., Tennessee.

*Distribution* (See fig. 8): *Type locality,* Ohio River (Rafinesque).

Wherever found, in Pennsylvania, as well as in the Tennessee-drainage, this form is associated with the main form, and does not show any remarkable facts in its distribution.

## PLEUROBEMA OBLIQUUM CATILLUS (Conrad) (1836).

*Quadrula solida* (LEA) SIMPSON, 1914, p. 885; *Pleurobema obliquum catillus* (CONRAD) and *Pleurobema catillus* (CONRAD) UTTERBACK, 1916, p. 79, 82.

Plate VI, fig. 6; Plate VII, fig. 2.

No records from Pennsylvania previous to those given below.

*Characters of variety:* This form may be briefly characterized as a *P. obliquum*, in which the radial furrow is obliterated. In all other respects it resembles the main species, and varies in the same way. The shell is more or less subtriangular, upright or somewhat oblique. The diameter is always considerable, fifty percent or more of the length. The nacre is generally white, rarely pinkish.

| | L. | H. | D. | Pr.ct. |
|---|---|---|---|---|
| *Size:* 1. Industry, Cat. No. 61.3895 | 83 mm. | 65 mm. | 48 mm. | .58 |
| 2. Industry, Cat. No. 61.3895 | 81 " | 69 " | 45 " | .56 |
| 3. Godfrey, Cat. No. 61.4567 | 61.5 " | 51 " | 32 " | .52 |

*Soft parts:* Identical with those of the main form, and also the *glochidia.*

*Breeding season:* Gravid females were found on May 22, 1914; June 22, 1909; June 24, 1909. Glochidia on June 24. Specimens from the White River in Arkansas were gravid, containing eggs on August 2 and 5, 1914.

*Remarks:* This form likewise is not sharply separated from the main species, and is connected with it by very gradual transitions, but it has a better claim to be recognized as a variety than var. *cordatum,* since it seems to replace the main species at least in certain regions. It has been largely misunderstood by previous authors,

and even Simpson did not recognize it clearly. In fact, two of the specimens of which he published the measurements (the first two) fall under the var. *coccineum.* The synonymy given by Simpson is correct, as far as it goes. But there is no doubt that *U. catillus* Conrad (1836), which is made by Simpson a synonym of *U. coccineus* should be united with *U. solidus* Lea. Its diameter is fifty-one percent of the length (according to Conrad's figure, Pl. 13, fig. 2), and its greater obesity is precisely the character which distinguishes it from *U. coccineus.* *U. solidus* (according to Lea's figure) has a diameter of sixty percent of the length, while *U. coccineus* Conrad (*ibid.*, Pl. 13, fig. 1) has the diameter thirty-seven percent of the length.

That *U. catillus* more nearly approaches *U. solidus,* was already recognized by Utterback, who also clearly saw that these forms in Missouri pass into each other and into *obliquum.* Utterback tried to express this in a very peculiar way by naming one of the intergrades *P. catillus,* and another *P. obliquum catillus,* but this can hardly find approval.

The Carnegie Museum possesses, from the Hartman collection, a specimen (Cat. No. 61.1440) from Cincinnati, labeled *U. solidus,* "type" (meaning typical), and "Lea datum." This, consequently, is an authentic specimen from Lea, from one of the type localities. It has a diameter of sixty-four percent, and thus corresponds closely with Lea's original figure, and with my conception of this form.

That *U. solidus* of Call (1900, Pl. 59, upp. fig.) is a typical *P. obliquum,* has been mentioned above. What Scammon (1906, Pl. 85) figures as a young *Quadrula solida,* is not this, but a rather good *P. obliquum rubrum.*

*Unio fulgidus* Lea (Obs. IV, 1848, Pl. 4, fig. 10), supposedly from Alexandria, Louisiana, is made by Simpson a synonym of *Q. solida.* It is founded upon a very young specimen, and I hardly think that it is possible to make out what it really is. However, Walker has communicated under the name of *fulgidus* a specimen from Iowa City, which undoubtedly belongs to *solidus* (= *catillus*). It has a rather shining epidermis, but otherwise closely resembles specimens labeled *solidus* by Walker. Such specimens seem to prevail west of the Mississippi, but I have them also from the Tennessee-drainage.

In Pennsylvania, *P. obliquum catillus* may be recognized by the absence of the radial furrow, the sutriangular outline, and considerable obesity. By the reduction of the latter, *i.e.*, when the shell becomes more compressed, it passes very gradually into the var. *coccineum,* and it is possible to separate the transitional forms only by exact measurements, and an artificial dividing line. I have drawn this line at the diameter of fifty percent of the length, but I again must emphasize

that this is arbitrary, separating things which are actually connected. However, for practical purposes (naming of specimens) it is a great help, and serves to simplify matters.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Ohio River, Shippingport, Cooks Ferry, and Industry, Beaver Co.; Coraopolis, Allegheny Co. (S. N. Rhoads).

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).

Mahoning River, Mahoningtown and Coverts, Lawrence Co.

Allegheny River, Natrona, Allegheny Co.; Aladdin, Godfrey, Johnetta, Kelly, and Templeton, Armstrong Co.; Walnut Bend, Venango Co.; Hickory, Forest Co.; Warren, Warren Co.

Cheat River, Cheat Haven, Fayette Co.

*Other localities represented in the Carnegie Museum:*

*Ohio-drainage:*

Ohio River, Toronto, Jefferson Co., Ohio; Steubenville, Jefferson Co., Ohio (W. F. Graham); St. Marys, Pleasants Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio; Cincinnati, Hamilton Co., Ohio (Hartman collection).

Tuscarawas River, Ohio (Holland collection).

*Tennessee-drainage:*

Duck River, Columbia, Maury Co., Tennessee (B. Walker, donor).

Tennessee River, Florence, Lauderdale Co. (H. H. Smith); Bridgeport, Jackson Co., Alabama (B. Walker, donor).

Holston River, Noeton, Grainger Co., Tennessee.

Clinch River, Edgemoor, Anderson Co.; Black Fox Ford, Union Co., Tennessee.

*West of Mississippi:*

Iowa River, Iowa City, Johnson Co., Iowa (B. Walker, donor).

Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).

Marais des Cygnes River, Rich Hill, Bates Co., Missouri (W. I. Utterback).

James River, Galena, Stone Co., Missouri (A. A. Hinkley).

White River, Cotter and Norfolk, Baxter Co., Arkansas (A. A. Hinkley).

Black River (H. E. Wheeler) and Spring River (A. A. Hinkley), Black Rock, Lawrence Co., Arkansas.

From other localities in southern Arkansas (Ouachita River) and in Oklahoma, similar forms are at hand, but I omit them here, since they require further study, chiefly with regard to their relation to the southwestern forms of *P. obliquum rubrum*, which are not at all clear. (See Wheeler, 1918, p. 124.)

*Distribution and Ecology in Pennsylvania* (See fig. 8): In the Ohio and Allegheny this form is found associated with typical *P. obliquum*. No specimens have come to hand from the Monongahela proper, but it must have existed there, since it turns up in the lower Cheat. In the Allegheny, it goes a great distance beyond the range of *P. obliquum*, up to Warren Co., but in this whole region it is associated with, and passes into, *P. obliquum coccineum*. It also has entered the Beaver River, and goes even up into the lower part of the Mahoning, passing again

into *coccineum*. It is interesting to see that it actually exists in the Mahoning, for one of the original localities mentioned by Lea for his *U. solidus*, is "Mahoning River, Ohio."

In the lower Allegheny and in the Ohio just below Pittsburgh, this form is even more abundant than the normal *P. obliquum*. It is found under the same conditions as the latter, but most abundantly upon gravel bars with strong current.

*General distribution: Type locality*, Scioto River, Ohio (Conrad).

This variety seems to be found wherever the typical form is present, that is to say, in the Ohio-, Cumberland-, and Tennessee-drainages; but particulars cannot be accurately expressed on account of the confusion which prevails with regard to it. It is certainly present in the upper Tennessee-drainage, going upstream about as far as *P. obliquum*. In addition this variety seems to be rather frequent west of the Mississippi, in regions where the typical *P. obliquum* is largely absent or doubtful, namely in Iowa, Missouri, and northern Arkansas. As has been indicated above, *P. catillus* seems there to replace *P. obliquum*, and in turn connects with the var. *rubrum*. This group of forms (*catillus-rubrum*) develops farther to the southwest into a peculiar assemblage, which cannot be discussed here. In Missouri there is shown a tendency on the part of *catillus* to pass into *coccineum* in small streams, exactly as is the case in Pennsylvania.

### Pleurobema obliquum coccineum (Conrad) (1836).

*Quadrula coccinea* (Conrad) Simpson, 1914, p. 883.

Plate VII, figs. 3, 4, 5.

*Records from Pennsylvania:*

Conrad, 1836 (Mahoning River, near Pittsburgh).[53]
Marshall, 1895 (Allegheny River, Warren Co.).
Rhoads, 1899 (Beaver River, Wampum, Lawrence Co.).
Ortmann, 1909*b*, p. 200.

*Characters of variety:* Differs from *P. obliquum* by the flat and compressed shell, less prominent beaks, and the absence of the radial furrow. In the latter character, it agrees with *P. obliquum catillus*, but differs from this in the compression, the diameter being less than fifty percent of the length. The shape of the shell is subtriangular or, on account of the low beaks, more or less subovate. Color of nacre very variable: white, salmon, or all shades of pink to deep red.

[53] The nearest point of the Mahoning to Pittsburgh is where it joins the Shenango to form the Beaver, at Mahoningtown, Lawrence Co., Pa. I have found this form at this place, and this should be regarded as the *Type locality*.

| | L. | H. | D. | Pr.ct. |
|---|---|---|---|---|
| *Size:* 1. Mt. Morris, Cat. No. 61.4574 | 111 mm. | 88 mm. | 43 mm. | .39 |
| 2. Larabee, Cat. No. 61.3350 | 100 " | 81 " | 49 " | .49 |
| 3. Eastbrook, Cat. No. 61.3349 | 88 " | 67 " | 32 " | .36 |
| 4. Mahoningtown, Cat. No. 61.3907 | 69 " | 59 " | 32 " | .46 |

*Soft parts* (See Ortmann, 1912, p. 263): I have seen several hundred females, many of them gravid, but in no case I have found marsupial structure in the inner gills. *Glochidia* (See Ortmann (1911*b*, Pl. 89, fig. 4) measurements: 0.15 × 0.15 mm., and Surber (1915, p. 7, fig. 9) measurements: 0.16 × 0.16 mm.).

*Breeding season:* Gravid females have been found on May 13, 1911; May 23, 1909; May 23, 1911; May 23, 1912; May 24, 1911; June 18, 1908; June 22, 1908; June 23, 1910; July 4, 1909; July 8, 1909; July 19, 1909. Glochidia have been found on June 18, June 23, and July 4. Thus this form is tachytictic, breeding from the middle of May to the middle of July, and beginning to discharge the glochidia in the second half of June.

*Remarks:* This form has been hitherto regarded as a good species. In its typical environment (small streams) it is, indeed, quite constant, although it varies a good deal. The shape may be different, from subrotund to subovate, or subtriangular, and quite often the lower posterior end is drawn out and even deflected, thus producing an outline recalling that of *P. obliquum rubrum.* Generally, there is no trace of a radial furrow, and the lateral faces are rather flat, only slightly convex, and without a posterior ridge. In obesity, this form varies greatly, and more swollen shells (See No. 2, under measurements) gradually pass into *P. obliquum catillus*, and this takes place in the downstream direction. In the upper Allegheny occasional individuals turn up, having the dimensions of *catillus;* such become more abundant in Armstrong Co., where they outnumber the *coccineum*-forms. Here also individuals turn up, which show the beginning of a radial furrow, which then lead to specimens with well-developed furrow, representing typical *obliquum.*

There is complete intergradation between these forms, and it is impossible to separate them except by drawing an artificial line.

Below Pittsburgh, in the Ohio, only a single *coccineum* has been found. Conditions similar to those in the Allegheny prevail in the Beaver-drainage.

The nacre of *coccineum* is of a reddish tint more frequently than is the case in any of the preceding forms.

*Localities in Pennsylvania, represented in the Carnegie Museum:*

*Ohio proper and Beaver-drainage:*

Ohio River, Cooks Ferry, Beaver Co.

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).

Connoquenessing Creek, Ellwood City, Lawrence Co. (G. H. Clapp & H. H. Smith; G. L. Simpson, Jr.); Harmony, Butler Co.

Slipperyrock Creek, Wurtemberg, Lawrence Co.

Neshannock Creek, Eastbrook and Volant, Lawrence Co.; Leesburg, Mercer Co.

Mahoning River, Mahoningtown (Type locality), and Coverts, Lawrence Co.

Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Sharpsville, Clarksville, Shenango, and Jamestown, Mercer Co.

Pymatuning Creek, Pymatuning Township, Mercer Co.

*Allegheny-drainage:*

Allegheny River, Aladdin, Godfrey, Kelly, and Templeton, Armstrong Co.; Tionesta and Hickory, Forest Co.; Warren, Warren Co.; Larabee, McKean Co.

Buffalo Creek, Harbison, Butler Co.

Conemaugh River, New Florence, Westmoreland Co.

Loyalhanna River, Idlepark and Ligonier, Westmoreland Co.

Crooked Creek, Rosston, Armstrong Co.

Little Mahoning Creek, Goodville, Indiana Co.

Sandy Creek, Sandylake, Mercer Co.

French Creek, Utica, Venango Co.; Cambridge Springs, Crawford Co.

Conneaut Outlet, Conneautlake, Crawford Co.

Conneauttee Creek, Edinboro, Erie Co.

Leboeuf Creek, Waterford, Erie Co.

Brokenstraw Creek, Garland, Warren Co.

Connewango Creek, Russell, Warren Co.

*Monongahela-drainage:*

Dunkard Creek, Mount Morris, Greene Co.

*Lake Erie-drainage:*

Conneaut Creek, Springboro, Crawford Co.; West Springfield, Erie Co.[54]

### *Other localities represented in the Carnegie Museum:*

*Lake-drainage:*

Shiawassee River, Genesee Co., Michigan (B. Walker, donor) (Saginaw-drainage).

Raisin River, Tecumseh, Lenawee Co., and Grape P. O., Monroe Co., Michigan (C. Goodrich).

St. Marys River, Rockford, Mercer Co., Ohio (C. Goodrich).

Swan Creek, Toledo, Lucas Co., Ohio (C. Goodrich).

*Ohio-drainage:*

Mahoning River, Leavittsburgh, Trumbull Co., Ohio (Smith collection).

Tuscarawas River, Ohio (Holland collection).

Scioto River, Ohio (Hartman collection).

Wabash River, Geneva, Adams Co., and Bluffton, Wells Co., Ind. (C. Goodrich).

West Fork River, Lynch Mines, Harrison Co., West Virginia; West Milford, Harrison Co., West Virginia (W. F. Graham); Lightburn and Weston, Lewis Co., West Virginia.

[54] The specimens from Conneaut Creek, which flows to Lake Erie, are all typical, medium-sized *coccineum*, with red nacre, which color is never found in the lake-form, and are not the latter (*paupereulum*).

Little Kanawha River, Grantsville, Calhoun Co. (W. F. Graham); Burnsville, Braxton Co., West Virginia.
Little Coal River, Boone Co., West Virginia (Hartman collection).
Licking River, Farmer, Rowan Co., Kentucky.

*Tennessee-drainage:*
Holston River, Hodges, Jefferson Co.; Noeton, Grainger Co., Tennessee.
Clinch River, Solway, Knox Co., Tennessee.

*West of Mississippi:*
James River, Galena, Stone Co., Missouri (A. A. Hinkley).
White River, Garfield, Benton Co., Arkansas (R. L. Moodie).

*Distribution and Ecology in Pennsylvania* (See fig. 8): In Pennsylvania, this form is widely distributed. It is especially abundant in the Beaver-drainage, and also in that of the upper Allegheny, going up far into the headwaters, reaching into Beaver and French Creek, Crawford and Erie Cos., and in the uppermost Allegheny, McKean Co. In the Monongahela-drainage, it is rare, at least in Pennsylvania, and found only in Dunkard Creek, but formerly it surely existed elsewhere in smaller creeks, which are now polluted. It becomes more abundant again in the headwaters of the Monongahela in West Virginia.

It is distinctly a form of the smaller creeks, and locally quite plentiful in them. It prefers sand and fine gravel, in or below riffles, where the current is rather lively, and generally it is deeply buried. It avoids coarse gravel, but may be found now and then in rough places.

As has been stated, farther down in the larger rivers, it passes into *P. obliquum catillus*, and with the change of the shape of the shell, there is also a change in its ecological preferences, or perhaps it might be true to say that the latter very likely is the cause of the former change. We have here a good example of the correlation of habitat and shape. *P. obliquum coccineum* is distinctly an ecological race of *P. obliquum* (and its variety *catillus*) characteristic of the fine gravel and sand of the smaller streams. In the Ohio below Pittsburgh *coccineum* is practically absent, only a single individual having been found.

Its presence in Conneaut Creek, a tributary of Lake Erie, should be noted. It appears that this form is not derived from the form found in Lake Erie (*pauperculum*), but is identical with the form present in the upper Beaver and French Creek-drainages. A crossing over the divide is in this case suggested, and it should not be forgotten, that the old Beaver Canal (now obliterated) once connected these systems.

*General distribution: Type locality*, Mahoning River, near Pittsburgh (Conrad) (See above, p. 78, footnote 53).

Simpson (1900) gives for this form: "entire upper Mississippi-drainage,"

while Call (1885) says: "from western New York to Kansas; south to the Holston River, Tennessee."

Very likely, this form is present in western New York in the Allegheny-drainage, judging from its presence in Pennsylvania both in Warren and McKean Cos., although Marshall (1895) reports it only from Lake Erie, no doubt referring to the variety *pauperculum*. In Ohio it is found all over the state (Sterki, 1907*a*), but definite reports are mainly from smaller streams.[55] It is known from the Mahoning River (Lea, Dean, 1890), Tuscarawas River (Dean, Sterki), Scioto River, and from Columbus (Lea). As in Pennsylvania so in Ohio it crosses over into the lake-drainage, and is found in the Cuyahoga (Dean) and Maumee-drainage (Carnegie Museum). It occurs also in the lake-drainage in southern Michigan (Walker, 1898). It is common in Indiana, and there also crosses into the lake-drainage, St. Marys and St. Josephs Rivers (Call, 1900). Wilson & Clark (1912, p. 42) observe that *coccineum* is found in the headwaters of the Kankakee River in Indiana, but that in the lower Kankakee and in the Iroquois River in Illinois it passes into a form belonging to the *obliquum*-group. In Illinois the same conditions seem to prevail (Baker, 1906) or at any rate it goes far up toward the north in that state.

As our localities show, this form is found in the tributaries of the Ohio in West Virginia and eastern Kentucky. Other records from Kentucky and from Tennessee are missing, except Call's statement, that it is found in the Holston. It is, indeed, present in the Holston and in the Clinch, but is quite rare there, and closely connected with the variety *catillus*.

Farther to the west and southwest there is the record from Coon River, Dallas Co., Iowa (Marshall, 1895), that from the drainage of Turkey, Wapsipinicon, and Volga Rivers, northeastern Iowa (Geiser, 1910), and that from Missouri (Utterback, 1916). It is said to be present in Kansas (Scammon, 1906), and is in northern Arkansas (see our specimens and Meek & Clark, 1912) and even in the Ouachita River, in Clark Co. (Wheeler, 1918). But in this direction, the limit of its range is obscure. It seems, that in this region likewise it prefers smaller streams, but this needs further investigation.

[55] Lea gives it from the Ohio at Marietta, Washington Co., Ohio, and it is in the Cincinnati-list (Harper, 1896); but these records are to be doubted. I have never found it in the Ohio, and the large shell-heaps of the clam-diggers examined by myself at various places never yielded a single individual of this shell,

### Pleurobema obliquum pauperculum (Simpson) (1900).

*Quadrula coccinea paupercula* Simpson, 1900, p. 789; *Quadrula subrotunda* Sterki, 1907*a*, p. 391 (*partim*); *Quadrula subrotunda* Ortmann, 1909*b*, p. 203 (*per errorem*); *Quadrula coccinea magnalacustris* Simpson, 1914, p. 884.[56]

Plate VII, fig. 6.

*Records from Pennsylvania:*

Ortmann, 1909*b*, p. 203 (as form of *Q. subrotunda*).

*Characters of variety:* Resembling *P. obliquum coccineum*, but shell considerably smaller, more convex (diameter ranges around fifty percent), with the outline subovate, and generally more elongate, and the growth-lines more distinct and quite regular. The beaks are not very prominent (hence the subovate, and not triangular, outline), and a furrow, except in extreme cases is absent, there being merely a flattening in its place. Nacre always white.

| | L. | H. | D. | Pr.ct. |
|---|---|---|---|---|
| *Size:* 1. Erie, Cat. No. 61.4393 (largest at hand) | 71 mm. | 50 mm. | 35 mm. | .49 |
| 2. Erie, Cat. No. 61.4393 | 70 " | 55 " | 34 " | .49 |
| 3. Erie, Cat. No. 61.4579 | 62 " | 48 " | 28 " | .45 |
| 4. Erie, Cat. No. 61.3930 (smallest at hand) | 55 " | 47 " | 29 " | .53 |

*Soft parts:* Only two individuals have ever been found alive by myself, of which the soft parts of one were preserved. It proved to be a male, with the structure agreeing with that of *P. obliquum*. The characteristic features of the females have not been observed. The color of the soft parts was grayish-white.

*Glochidia* and *breeding season* unknown.

*Remarks:* As Simpson correctly recognized, this is a form derived from *coccineum*, and not directly from *obliquum:* nevertheless, the rules of nomenclature force us to use the above name.

This is the Lake Erie form of *coccineum*, descended from the stock which crossed the divide between the upper Ohio and the lake-drainages in northern Indiana, Ohio, and possibly Pennsylvania. This lacustrine form has the distinct and regular growth-lines, which are also more closely set, found so often in shells from Lake Erie, and this peculiarity together with its small size are its chief diagnostic characters. In shape it is generally more elongate-ovate than *coccineum*, but, according to the growth-lines, young specimens must be shorter and more rounded-ovate. On the average it is slightly more swollen than *coccineum*, but

[56] The change of the varietal name introduced by Simpson in 1914 is unnecessary. There is a *Unio pauperculus* Lea (1861) but this does not constitute a pre-occupation of the term *Quadrula coccinea paupercula*.

the difference in this respect is not great. There is much variation in shape, chiefly with regard to the elongation of the shell and the position of the beaks. In some specimens the beaks are much anterior, thus imitating the condition seen in *P. obliquum rubrum*.

The color of the epidermis is generally dark brown, but specimens from Michigan are light brown, with greenish capillary rays; however, these specimens are greatly water-worn.

I have not seen any specimens grading toward the parent-form, and for this reason, we might perhaps be justified in regarding this as a true species. Nevertheless I hesitate to take this course, since I consider my material (about fifteen specimens) as insufficient to settle this question.

*Localities represented in the Carnegie Museum:*

Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania.
Lake Erie, La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).

*Distribution and Ecology* (See fig. 8): *Type locality*, St. Lawrence basin at Niagara Falls (Simpson).

Sterki mentions this form, as a dwarf race of *Q. subrotunda*, from the Ohio shores of Lake Erie. Walker gives it (1913, p. 29) from Lake Erie, and probably his *Q. subrotunda* refers to the same form. I have found it in Presque Isle Bay, and received specimens from La Plaisance Bay. Probably, Marshall's (1895) *U. coccineus* from Erie Co., New York, is also this.

Our present knowledge thus limits its range to Lake Erie and the Niagara River just below it. Simpson, indeed, says "and tributaries," but exact localities are not given.

In Presque Isle Bay I found this shell only on the North shore in a few feet of water upon pure sand, but most of my specimens were dead shells. It is decidedly rare at this locality.

### Pleurobema obliquum rubrum (Rafinesque) (1820).

*Quadrula pyramidata* (Lea) Simpson, 1914, p. 888; *Quadrula rubra* (Rafinesque) Vanatta, 1915, p. 557.

Plate VI, fig. 7.

*Records from Pennsylvania:*

Harn, 1891 (as *mytiloides*) (western Pennsylvania).
Stupakoff, 1894 (Allegheny Co.).
Ortmann, 1909*b*, p. 199 (under *obliqua*).

*Characters of variety:* Like *P. obliquum*, but shell very oblique, with the beaks

strongly procurved, and situated at the anterior end of the shell. Radial furrow more or less distinct. Diameter generally considerably over fifty percent of the length, but sometimes less. Nacre typically red, but sometimes pinkish or white.

| | L. | H. | D. | Pr.ct. |
|---|---|---|---|---|
| *Size:* 1. Industry, Cat. No. 61.3896 | 91 mm. | 73 mm. | 54 mm. | .59 |
| 2. Kelly, Cat. No. 61.3079 | 86 " | 71 " | 47 " | .55 |
| 3. Godfrey, Cat. No. 61.3891 | 63 " | 53 " | 36 " | .57 |

*Soft parts* (See Ortmann, 1912, p. 264): *Glochidia* not yet observed.

*Breeding season:* Gravid specimens are at hand collected on May 25, 1914 and July 28, 1913. They all had eggs only.

*Remarks:* There is not the slightest doubt that this is in Pennsylvania only an individual variation of *P. obliquum*, characterized by excessive obliquity. There is great variation in this respect, and complete connection with the main form. While the nacre is mostly red in typical specimens from the Tennessee, in Pennsylvania it is more frequently pink or whitish. Altogether, typical *rubrum* is quite scarce in our state, but, as our fig. 7 on Pl. VI shows, it is present, and does not differ at all from specimens from the Tennessee. The intergrades toward *P. obliquum* are much more abundant with us.

Considering the conditions in Pennsylvania alone, I should never have thought of giving this form varietal rank. But in other regions, it is more distinctly marked, as for instance in the Upper Tennessee-drainage. Here the var. *rubrum* in its typical phase is quite abundant and rather sharply distinguished. However, here also are found forms representing transitions to *obliquum* and *catillus*. In the region west of the Mississippi, where *P. obliquum* is practically missing, the var. *rubrum* (and *catillus*) are found in its place, and thus it seems to be advisable to retain *rubrum* as a distinct variety. These western forms require still closer study.

I want to emphasize this instance, for it demonstrates that a certain form may be in a certain region an individual variation of another form, while in other regions it becomes a better defined local race, or variety.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Ohio River, Shippingport and Industry, Beaver Co.; Neville Island, Allegheny Co.
Allegheny River, Godfrey and Kelly, Armstrong Co.

*Other localities represented in the Carnegie Museum:*

*Ohio-drainage:*

Ohio River, St. Marys, Pleasants Co., West Virginia; Portsmouth, Scioto Co., Ohio.
Tuscarawas River, Ohio (Holland collection).
West Fork of White River, Riverside, Greene Co., Indiana (J. D. Haseman).

*Tennessee-drainage:*

Tennessee River, Knoxville, Knox Co., Tennessee.

French Broad River, Boyd Creek, Sevier Co., Tennessee.

Holston River, McMillan and Mascot, Knox Co.; Hodges, Jefferson Co.; Turley Mill, Noeton, and Holston Station, Grainger Co.; Austin Mill, Hawkins Co., Tennessee.

Clinch River, Solway, Knox Co.; Edgemoor and Offutt, Anderson Co.; Needhams Ford (B. Walker, donor) and Black Fox Ford, Union Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee.

There are a good many specimens at hand from west of the Mississippi, from Arkansas, Kansas, and Oklahoma, but since these form a peculiar and rather obscure association of forms, partly intergrading with the var. *catillus*, partly having characters of their own, I omit them here, till further investigations have been made.

*Distribution in Pennsylvania* (See fig. 8):

The range of this form in Pennsylvania, is coëxtensive with that of *P. obliquum*, but it is rather rare. The same is true farther down the Ohio, and wherever I collected it myself between Pittsburgh and Cincinnati I found only a few specimens of it among large numbers of *obliquum* and its intergrades.

*General distribution: Type locality*, Kentucky River (Rafinesque).

Where *P. obliquum* is found, this form generally is also present. However, *P. obliquum rubrum* seems to have a wider range than the main form, for it is also found west of the Mississippi without being associated with *P. obliquum* (See above). I also have observed in the upper Tennessee-drainage, that it ascends in the Holston and Clinch a little farther than the main species.

*Note:* Attention should be called again to the fact, that we have here a group of forms (*obliquum-group*), of which some have swollen shells (*obliquum* and *catillus*), which are found in the larger rivers, while another allied form has a compressed shell (*coccineum*), which is peculiar to small creeks. As in certain other cases, there is also a dwarfed lacustrine form, *pauperculum*.

It is well to keep these facts in mind. My observations on the passing of the creek form into that of the large rivers have been confirmed for the Kankakee-drainage in Indiana and Illinois by Wilson & Clark (1912, p. 42). However, the remark of these authors, that I am of the opinion that these forms are "identical" rests upon a misunderstanding. They are "conspecific," and represent well marked races, or varieties, of the same species, but they are not *identical*.

## Pleurobema clava (Lamarck) (1819).

*Pleurobema clava* (Lamarck) Simpson, 1914, p. 735.

Plate VII, figs. 7, 8, 9.

*Records from Pennsylvania:*

Call, 1885 (Allegheny River, as *U. patulus*).

Harn, 1891 (western Pennsylvania).

Marshall, 1895 (Allegheny River, Warren Co.).
Ortmann, 1909*b*, p. 197.

*Characters of the shell:* Shell small, or barely of medium size, but comparatively heavy. Outline subtriangular to subovate, more or less elongated and drawn out posteriorly, very oblique, often cuneiform (high in front, tapering behind). Lower margin convex or straight. Beaks not much elevated, moderately swollen, directed obliquely forwards, and situated near the anterior end of the shell, sometimes quite anterior. Beak-sculpture rudimentary, indistinct, consisting of three to four subconcentric ridges. Shell more or less swollen anteriorly, less swollen and more compressed posteriorly; sometimes with the anterior swelling marked off quite sharply from the posterior flat part, but hardly ever with a distinct radial depression. In most cases the swollen anterior part passes insensibly into the compressed posterior part. In some cases the shell is very little swollen anteriorly, and the valves are rather regularly and gently convex. No distinct posterior ridge. Surface of shell smooth, without sculpture.

Epidermis yellowish to light brown or pale chestnut, darker when old; generally with more or less distinctly green capillary rays, which are interrupted and much broken, forming very often, and characteristically, squarish, or even transverse green to blackish spots or blotches. Growth-rests not very different in color.

Hinge well-developed. Pseudocardinals divergent, moderately large, ragged. Interdentum not very wide, often rather narrow. Lateral teeth rather long. Beak-cavity not deep. Dorsal muscle-scars on the hinge-plate. Nacre always white.

No sexual differences in the shell.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Harbor Bridge, Cat. No. 61.3815 (largest) | 78 mm. | 51 mm. | 36 mm. |
| 2. Eastbrook, Cat. No. 61.3335 | 74 " | 48 " | 27 " |
| 3. Eastbrook, Cat. No. 61.3335 | 64 " | 40 " | 23 " |
| 4. Eastbrook, Cat. No. 61.3335 | 54 " | 35 " | 21 " |
| 5. Mosgrove, Cat. No. 61.4328 | 39 " | 29 " | 19 " |

*Soft parts* (See Ortmann, 1912, p. 264, fig. 9). *Glochidia* (See Ortmann, 1911*b*, Pl. 89, fig. 5).

*Breeding season:* The following records are at hand for gravid females: May 22, 1912; May 23, 1911; May 23, 1912; May 24, 1911; June 18, 1908; June 27, 1910; July 8, 1909; July 8, 1911; July 10, 1908; July 19, 1909. Glochidia have been found as early as June 18. Tachytictic form, breeding from about the middle of May to the end of July.

*Remarks:* A very distinct species, at least in Pennsylvania. It belongs to

the smaller mussels, and its chief characters are the peculiar, obliquely-ovate, elongated or cuneiform outline, and the light color of the epidermis, with green patches, which are frequently (but not always) present. In shape, situation of beaks, and obesity, it varies greatly (compare, for instance the figure of Lea's *patulus*, Obs. I, 1834, Pl. 12, fig. 20, and of Conrad's *clava*, Mon. 1835, Pl. 5, fig. 1). In old specimens the beaks are sometimes quite anterior, forming the foremost point of the shell, but such extremes are rare in Pennsylvania, and generally the beaks remain a little behind the anterior margin of the shell. Also with regard to the convexity of the valves no extreme cases have been observed in Pennsylvania; on the contrary the tendency is more toward the flatter types (corresponding more nearly to *patulus*).

The peculiar color-markings are present in most specimens, but extremely variable. The spots are found chiefly towards the beaks, and often an irregular

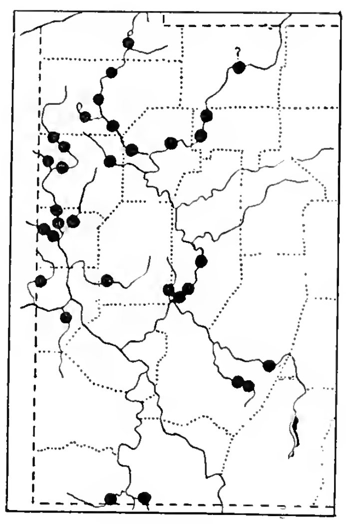

Fig. 9.

● *Pleurobema clava.*

series of these spots runs down just in front of the posterior slope. In old shells, the epidermis tends to become uniformly brown.

*Localities in Pennsylvania, represented in the Carnegie Museum:*

*Ohio-drainage:*

Little Beaver Creek, Cannelton, Beaver Co. (Miss Vera White).

Raccoon Creek, Raccoon Township, Beaver Co.

*Beaver-drainage:*

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).

Connoquenessing Creek, Harmony, Butler Co.

Mahoning River, Mahoningtown and Coverts, Lawrence Co.

Neshannock Creek, Eastbrook, Lawrence Co.
Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Clarksville, Shenango, and Jamestown, Mercer Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.

*Allegheny-drainage:*
Allegheny River, Aladdin, Godfrey and Mosgrove, Armstrong Co.; Walnut Bend, Venango Co.; Tionesta and Hickory, Forest Co.
Buffalo Creek, Harbison, Butler Co.
Conemaugh River, New Florence, Westmoreland Co.
Loyalhanna River, Idlepark and Ligonier, Westmoreland Co.
Sandy Creek, Sandylake, Mercer Co.
French Creek, Utica, Venango Co.; Cochranton, Meadville, and Cambridge Springs, Crawford Co.
Conneaut Outlet, Conneautlake, Crawford Co.
Leboeuf Creek, Waterford, Erie Co.

*Monongahela-drainage:*
Dunkard Creek, Mount Morris, Greene Co.
Cheat River, Cheat Haven, Fayette Co.

*Other localities represented in the Carnegie Museum:*

*Lake-drainage:*
Maumee River, Defiance, Defiance Co., Ohio, and Fort Wayne, Allen Co., Indiana (C. Goodrich).

*Ohio-drainage:*
Tuscarawas River, Ohio (Holland collection).
Wabash River, Geneva, Adams Co., Indiana (C. Goodrich).
West Fork River, Lynch Mines, Harrison Co.; Lightburn and Weston, Lewis Co., West Virginia.
Little Kanawha River, Burnsville, Braxton Co., West Virginia.
North Fork Hughes River, Cornwallis, Ritchie Co., West Virginia.
Elk River, Sutton and Gassaway, Braxton Co.; Shelton, Clay Co., West Virginia.

*Tennessee-drainage:*
Tennessee River, Tuscumbia, Colbert Co., Alabama (H. H. Smith).

*Distribution and Ecology in Pennsylvania* (See fig. 9): The range of this species in Pennsylvania is very similar to that of *P. obliquum coccineum*, with the exception that it does not go into the lake-drainage. The two forms are very often found associated. *P. clava* does not go up the Allegheny as far as *coccineum* does.[57]

Altogether, *P. clava* is a rare shell, and never found in great numbers. It is found mostly in sand and fine gravel, and is deeply buried. In the large rivers it is missing. The lowest point in the Allegheny is at Aladdin. It has never been found in the Monongahela proper and in the Ohio, and is also missing in the lists of the older collectors (Stupakoff, Clapp, Rhoads). The same holds good farther down the Ohio. I have never seen a trace of it between Pittsburgh and Cincinnati.

*General distribution: Type locality,* "Lake Erie" (Lamarck).

[57] I found *P. clava* as far up as Hickory, Forest Co., but Marshall (1895) reports it from Warren Co.

We have here the curious fact that a species is not found at its type locality. It should be noted, however, that this species is present in tributaries of the lake, chiefly in the Maumee (Goodrich, 1914) substantiated by specimens in the Carnegie Museum.

Although Call (1895 and 1900) cites western New York and the Ottawa River, Canada, for this species, there is serious doubt whether it goes so far north and northeast. No exact localities are known in the Allegheny River in the state of New York, nevertheless this species might be there, since it has been reported from Warren Co., Pennsylvania, and is positively found immediately below in Forest Co. Its main range includes the Ohio, Cumberland, and Tennessee systems, chiefly in their tributaries. It is widely distributed in these drainages in western Pennsylvania, Ohio, Indiana, West Virginia, Kentucky, Tennessee, and northern Alabama. In Ohio and Indiana it surely crosses over into the lake-drainage, St. Marys and Maumee Rivers (Call, 1900, and Sterki, 1907*a*, also collected by C. Goodrich). Nevertheless it has not been reported from Lakes Erie and Michigan (See Walker, 1898 and 1913). Remarkably enough, while it is widely distributed in Indiana (Call, 1896*a* and 1900), it is listed from Illinois (by Baker, 1906) only from the Wabash. Its actual absence in the rest of Illinois is confirmed by the recent investigations of Wilson and Clark. According to them it is in Tippecanoe Lake (Wabash-drainage) in Indiana, but not in the Kankakee-drainage in Indiana and Illinois. West of Illinois, only three records are at hand (from Iowa City, Iowa; St. Peters River, Minnesota; and Nebraska), which, however, are very likely incorrect (Simpson, 1900, p. 746 seems to have no confidence in them, and Geiser (1910) does not give this shell from northeastern Iowa). No other records are known from west of the Mississippi.

In the Tennessee-drainage, this species surely goes to northern Alabama. In the upper Tennessee region it is missing but there are a number of closely allied species or forms, the standing of which will be elucidated elsewhere; also in the Coosa-Alabama-drainage there are representatives, which have been taken for synonyms, for instance by Call. But this surely is incorrect, and requires further study.

It is not known, whether this species outside of Pennsylvania inhabits preferably the smaller streams, except that it is surely present in them in West Virginia.

## Genus Elliptio Rafinesque (1820).

Ortmann, 1912, p. 265; Simpson, 1914, p. 586 (as section of *Unio*).
Type *Unio nigra* Rafinesque.

Five species and one variety are found in Pennsylvania (one of them somewhat doubtful as to its presence in the state).

Key to the Pennsylvanian Species and Variety of Elliptio.

$a_1$. Shell very large, rhomboid-ovate, not elongated, with a sharp posterior ridge. Posterior slope (at least in the young) with radiating wrinkles. (Western shell.) .................... *E. niger.*

$a_2$. Shell larger or smaller, elongated ovate, or subtrapezoidal, with ill defined or no posterior ridge. Posterior slope not wrinkled.

- $b_1$. Shell rather large, elongated ovate, heavy, not subtrapezoidal, somewhat inflated or subcompressed. (Western shells.)
  - $c_1$. Shell larger, subcompressed. Epidermis dark colored, with obscure growth-lines. *E. dilatatus.*
  - $c_2$. Shell smaller, more swollen and thus more nearly subcylindrical. Epidermis of lighter color, with more distinct and more regular growth-lines............ *E. dilatatus sterkii.*
- $b_2$. Shell moderately large or small, subtrapezoidal, more or less elongated, and more or less compressed. (Eastern shells.)
  - $c_1$. Shell moderately large, subtrapezoidal, slightly elongated, not much pointed behind. *E. violaceus.*
  - $c_2$. Shell moderately large or small, subtrapezoidal, but much elongated, so as to become lance-shaped, pointed behind.
    - $d_1$. Shell rather small, upper and lower margins nearly parallel; greatest height in the middle portion................................................... *E. cupreus.*
    - $d_2$. Shell somewhat larger, upper and lower margins not subparallel; greatest height more anteriorly................................................... *E. fisherianus*

## Elliptio niger (Rafinesque) (1820).

*Unio crassidens* Lamarck. Simpson, 1914, p. 606.
Plate VIII, fig. 1.

*Records from Pennsylvania:*

Call, 1885 (Allegheny River).
Harn, 1891 (western Pennsylvania).
Clapp, 1895 (Allegheny Co.).
Marshall, 1895 (Allegheny River, Warren Co.).[58]
Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co.).
Ortmann, 1909*b*, p. 197.

*Characters of the shell:* Shell large and very heavy. Outline ovate-rhomboid, rather variable, shorter or longer, but always longer than high, but rarely almost

[58] This record is doubtful. I have never seen this striking shell in the Allegheny above Oil City.

twice as long as high. Anterior end rounded, lower posterior end more or less produced and bluntly pointed. Lower margin convex, straight, or even sometimes slightly concave in its posterior part. Beaks not greatly swollen and not very prominent, situated in advance of the middle of the shell, but not very near the anterior end. Beak-sculpture very rudimentary, almost obliterated, consisting of a few weak concentric ridges running parallel with the growth-lines. Shell moderately swollen towards the beaks, but sides of the disk only gently convex, often quite flat posteriorly. A distinct and rather sharp posterior ridge runs from the beaks toward the lower posterior end. The posterior slope behind this ridge is subtruncate and flat, and toward the beaks it is generally ornamented with fine radiating wrinkles or corrugations. The latter are chiefly seen in young shells, are irregular and often interrupted. Upon old shells they are absent, mostly destroyed by the erosion of the beaks; sometimes they occur also in young specimens poorly developed, or are absent. Otherwise the surface of the shell is smooth, without sculpture.

Epidermis brown, from reddish brown to dark blackish brown; in the young it is lighter brown, and generally marked by dark green, obscure rays, which are narrower or wider, but in adult shells the rays disappear entirely. Growth-rests not distinctly marked by color.

Hinge-teeth well-developed and very strong. Pseudocardinals divergent, large, and ragged. Interdentum rather narrow. Lateral teeth thick and rather long. Beak-cavity not deep. Dorsal muscle-scars on the hinge-plate. Nacre always some shade of red. Very rarely it is almost white in the centre of the shell, and then some color is always present around the margins. In most cases, the whole nacre is tinted, and the color ranges from a beautiful salmon through all shades of pink and red to a blueish purple.

No sexual differences in the shell.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Kelly, Cat. No. 61.3777 | 129 mm. | 85 mm. | 49 mm. |
| 2. Cooks Ferry, Cat. No. 61.4427 | 125 " | 87 " | 57 " |
| 3. Kelly, Cat. No. 61.3055 | 117 " | 73 " | 44 " |
| 4. Neville Island, Cat. No. 61.926 | 119 " | 85 " | 56 " |
| 5. Kelly, Cat. No. 61.3059 | 89 " | 60 " | 43 " |
| 6. Shippingport, Cat. No. 61.4607 | 63 " | 42 " | 23 " |

*Soft parts* (See Ortmann, 1912, p. 266, fig. 10). *Glochidia* (See Ortmann, 1911*b*, Pl. 89, fig. 6) not quite mature, size: $0.13 \times 0.15$ mm. Mature glochidia have been described and figured by Surber (1915, p. 8, fig. 13). Their shape is somewhat pointed (subtriangular); their size: $0.15 \times 0.16$ mm.

*Breeding season:* Gravid females have been found only once by myself, on June 22, 1909 (with eggs and young glochidia). Surber secured them on July 14, 1911. Thus the duration of the breeding season remains uncertain, but probably is short, and ends in July.

*Remarks:* A very characteristic species, which cannot be confused with any other form. In fact Rafinesque's definition of *U. nigra* as a "large, heavy shell,

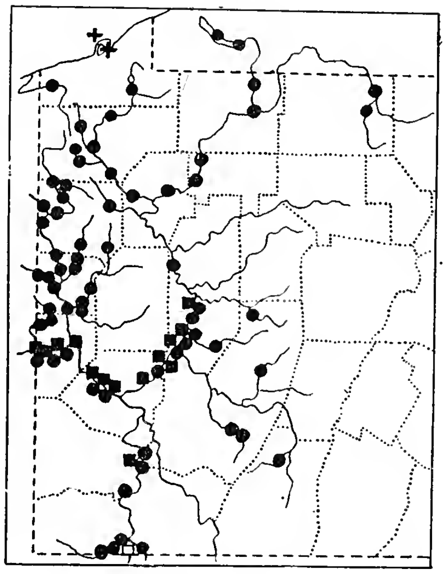

Fig. 10.

■ *Elliptio niger.*
□ *do. do.* (Indian garbage heap.)
● *Elliptio dilatatus.*
+ *Elliptio dilatatus sterkii.*

with red nacre, from the Ohio," is entirely satisfactory. The shell varies greatly in shape, and may be shorter or longer in proportion to height, but is always recognized by its subovate outline, the distinct posterior ridge, and the color of the nacre. The peculiar sculpture of the posterior slope is well-developed only in young shells.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Ohio River, Smiths Ferry (W. F. Graham), Shippingport, Cooks Ferry, Industry, and Beaver, Beaver Co.; Shoustown (R. Fœrster), Coraopolis (S. N. Rhoads), and Neville Island, Allegheny Co.

Allegheny River, Harmarville and Natrona, Allegheny Co.; Braeburn, Westmoreland Co.; Aladdin, Godfrey, Johnetta, Kelly, and Templeton, Armstrong Co.

Monongahela River, Charleroi, Washington Co. (G. A. Ehrmann).

*Other localities represented in the Carnegie Museum:*

*Ohio-drainage:*

Ohio River, Congo, Hancock Co., West Virginia; Toronto, Jefferson Co., Ohio; St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.

West Fork White River, Riverside, Greene Co., Indiana (J. D. Haseman).

Elk River, Gassaway, Braxton Co., and Shelton, Clay Co., West Virginia.

Levisa Fork, Big Sandy River, Prestonsburg, Floyd Co., Kentucky.

*Tennessee-drainage:*

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).

Paint Rock River, Paint Rock, Jackson Co., Alabama (H. H. Smith).

Tennessee River, Concord and Knoxville, Knox Co., Tennessee.

French Broad River, Boyd Creek, Sevier Co., Tennessee.

Nolichucky River, Chunns Shoals, Hamblen Co., Tennessee.

Holston River, McMillan and Mascot, Knox Co.; Hodges, Jefferson Co.; Nocton, Grainger Co.; Austin Mill, Hawkins Co., Tennessee.

South Fork Holston River, Pactolus, Sullivan Co., Tennessee.

Clinch River, Solway, Knox Co.; Edgemoor, Clinton, and Offutt, Anderson Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Clinchport, Scott Co., Virginia.

Emory River, Harriman Junction, Roane Co., Tennessee.

*Gulf-drainage:*

Pearl River, Mississippi (Juny collection).

Black Warrior River, Squaw Shoals, Jefferson Co., Alabama (H. H. Smith).

Cahaba River, Pratts Ferry, Bibb Co., and Gurnee, Shelby Co., Alabama (H. H. Smith).

Coosa River, Wetumpka, Elmore Co.; Weduska and Peckerwood Shoals, and Wilsonville, Shelby Co.; Coosa Valley and Riverside, St. Clair Co., Alabama (H. H. Smith).

Choccolocco Creek, Jackson Shoals, Talladega Co., Alabama (H. H. Smith).

Chattooga River, Cedar Bluff, Cherokee Co., Alabama (H. H. Smith).

Etowah River (R. E. Call) and Oostanaula River (G. H. Clapp, donor), Rome, Floyd Co., Georgia.

Sepulga River, Herbert, Conecuh Co., Alabama (Alabama Museum, donor).[59]

*Distribution and Ecology in Pennsylvania* (See fig. 10): This is a species restricted to the large rivers, Ohio, Allegheny, and Monongahela, but extremely abundant in them. I have never seen it in the Allegheny above Templeton in Armstrong Co. In the Monongahela it once must have gone up above Charleroi at least as far as the West Virginia state-line, since I have found it in an Indian garbage-heap at Point Marion (See Ortmann, 1909*c*, p. 13).

*Elliptio niger* lives preferably in coarse gravel, often among heavy stones, in strongly flowing water, to which habitat it is especially adapted by its heavy, strong shell. Call (1900, p. 510) gives as its habitat "muddy bottoms," which is

[59] The specimens from the Coosa-drainage have in part been labeled by Walker as *U. incrassatus* Lea. But I consider them to be *E. niger*. They reach a considerable size, while the real *U. incrassatus* from the Chattahoochee River is a dwarf form.

not at all true for Pennsylvania. In the Ohio this shell is also found in great numbers on the shell-banks, consisting of masses of dead and broken shells, the interspaces filled with sand and gravel, in strong, steady currents. The same is the case farther down the Ohio, where it is taken in immense numbers by the clam-diggers, but rejected on account of the color of its nacre.

*General distribution: Type locality*, Ohio River (Rafinesque).

A common shell all along the Ohio from western Pennsylvania through Ohio, West Virginia, Kentucky, Indiana, and Illinois. Also in the Mississippi in Illinois, Iowa, and North to Minnesota, Winona Co. (See Holzinger, 1888). It goes only into the larger tributaries. In Ohio, it is in the Muskingum River at Marietta, Washington Co. (Hildreth, 1828), but not in the Tuscarawas River; it occurs in the Scioto River (Sterki, 1907*a*). In Indiana it is known from the Wabash (Call, 1900, Goodrich, 1914), and White River (Carnegie Museum). In Illinois it is found in the Wabash, and also in the Kaskaskia and Spoon Rivers (Baker, 1906). In Iowa, it is in the Wapsipinicon, at Independence, Buchanan Co. (Geiser, 1910). In West Virginia, I have discovered it in Elk River (tributary to the Kanawha). This river, and the Levisa Fork of the Big Sandy, are the smallest streams, in which I have found it.

Additional records from Kentucky are missing, but this species is known from the Cumberland, Tennessee, Duck, Holston, and Clinch Rivers in Tennessee.

In addition, it is widely distributed in the Alabama-drainage. The connection of this range with the main range seems to be over the Gulf plain; but this requires further study. The form from Alabama is indistinguishable from the Ohio form, but, judging from the material at hand, not quite so large. Eastward in the Chattahoochee in Georgia this form passes into a still smaller form, called *E. incrassatus*.

### Elliptio dilatatus (Rafinesque) (1820).

*Unio gibbosus* Barnes. Simpson, 1914, p. 597; *Unio dilatata* Rafinesque, Vanatta, 1915, p. 555; *Elliptio dilatata* (Rafinesque) Utterback, 1916, p. 90.

Plate VIII, fig. 2.

*Records from Pennsylvania:*

Harn, 1891 (western Pennsylvania).
Stupakoff, 1894 (Allegheny Co.).
Marshall, 1895 (Allegheny River, Warren Co.).
Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co.; Beaver River, Wampum, Lawrence Co.).
Ortmann, 1909*b*, p. 197.

*Characters of the shell:* Shell rather large and heavy. Outline elongate-ovate, generally about twice as long as high, and often longer. Anterior end rounded, posterior end produced and narrowing, but blunt. Lower margin gently convex, straight, or even slightly concave. Upper margin curving gently down into the upper posterior margin, without forming a distinct angle, and thus the shell is not subtrapezoidal. Beaks not prominent, situated near the anterior end. Beak-sculpture distinct, consisting of four to five rather heavy bars; the first two are subconcentric, the following ones run in the direction of the growth-lines, are almost straight in the middle, with the anterior and posterior parts obliterated; sometimes an indication of a sinuation is seen a little behind the middle. Shell somewhat swollen in the anterior part and toward the beaks; less swollen and almost flat, sometimes even compressed posteriorly and toward the lower margin, without a distinct posterior ridge. Surface smooth, without any sculpture.

Epidermis brown to black. In young specimens, traces of greenish rays are discernible, but generally the color is rather uniform, and the growth-rests are likewise not marked by darker color.

Hinge-teeth well-developed, but not very heavy. Pseudocardinals divergent, ragged. Interdentum rudimentary or absent. Lateral teeth long. Beak-cavity shallow. Dorsal muscle-scars in the beak-cavity. Nacre white or variably colored from light pink and salmon to deep purple, and coppery purple; often parti-colored, white and salmon, white and purple, salmon and purple, etc.

No sexual differences in the shell.

| | L. | H. | D. | Pr.ct. |
|---|---|---|---|---|
| *Size:* 1. Jamestown, Cat. No. 61.3752 (largest at hand) | 136 mm. | 61 mm. | 33 mm. | .24 |
| 2. Industry, Cat. No. 61.3763 | 122 " | 55 " | 33 " | .27 |
| 3. Greenville, Cat. No. 61.3329 | 91 " | 37 " | 27 " | .30 |
| 4. Wampum, Cat. No. 61.2889 | 54 " | 26 " | 13 " | .24 |

*Soft parts* (See Ortmann, 1912, p. 271). The *Glochidia* have been figured by Lea (Obs. XIII, 1874, Pl. 21, fig. 10), by Lefevre & Curtis (1910, p. 97, fig. N, & 1912, p. 146, fig. O) by Ortmann (1911*b*, Pl. 89, fig. 7) and Surber (1912, Pl. 2, fig. 38).

*Breeding season:* I have found several hundreds of gravid females on numerous dates between May 11 and August 13. Glochidia have been seen as early as June 5; but on the latest date (August 13) a specimen with eggs was observed. This is clearly an abnormal case. Surber (1912, p. 7) gives the breeding season as from June to August, but it begins before the middle of May. The species is typically tachytictic.

*Remarks:* I know of only two species in Pennsylvania, with which the present species might be confounded according to the general shape: *Ellipsaria fasciolaris* (Rafinesque) and *Eurynia recta* (Lamarck). The former is easily distinguished by the light, yellowish brown color of the epidermis, variegated with green rays and blotches; the latter is a straighter shell, more pointed behind, with a greenish black and shining epidermis.

*Elliptio dilatatus* is variable chiefly in size. In the larger rivers generally, and sometimes also in smaller creeks, it grows to a considerable length; while in other streams, chiefly those of the mountains, it remains rather small. Its general shape is rather uniform: it always is an elongated shell, produced and tapering behind, with no indication of a trapezoidal outline, and with a bluntly pointed posterior end. Its nacre is very variable in color, but while in the Ohio and Allegheny all shades are found, and shells with white nacre are quite abundant, in other sections, as for instance in the whole Beaver-drainage, shells with light-colored nacre are extremely rare. There is no tendency to form local races, except that a dwarfed form prevails in the mountain-streams.

*Localities in Pennsylvania represented in the Carnegie Museum:*

*Ohio-drainage:*

Ohio River, Smiths Ferry, Shippingport, Cooks Ferry, and Industry, Beaver Co.; Coraopolis (S. N. Rhoads) and Neville Island, Allegheny Co.

Little Beaver Creek, Cannelton (Miss Vera White), Darlington, and New Galilee, Beaver Co.; Enon Valley, Lawrence Co.

*Beaver-drainage:*

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).

Connoquenessing Creek, Ellwood City, Lawrence Co. (G. L. Simpson, Jr.).

Slipperyrock Creek, Wurtemberg and Rose Point, Lawrence Co.

Wolf Creek, Grove City, Mercer Co.

Mahoning River, Mahoningtown, Coverts, Edinburg, and Hillsville, Lawrence Co.

Neshannock Creek, Eastbrook and Volant, Lawrence Co.; Leesburg, Mercer Co.

Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Sharpsville, Clarksville, Shenango, and Jamestown, Mercer Co.

Pymatuning Creek, Pymatuning Township, Mercer Co.

Little Shenango River, Greenville, Mercer Co.

*Allegheny-drainage:*

Allegheny River, Natrona, Allegheny Co.; Schenley, Aladdin, Godfrey, Johnetta, Kelly, Mosgrove, Templeton, and Parkers Landing, Armstrong Co.; Walnut Bend, Venango Co.; Tionesta and Hickory, Forest Co.; Warren, Warren Co.; Larabee, McKean Co. (Dennis Dally).

Loyalhanna River, Idlepark and Ligonier, Westmoreland Co.[60]

Yellow Creek, Homer, Indiana Co.

[60] Dead shells have been seen in the Conemaugh River, at New Florence, Westmoreland Co.

Quemahoning Creek, Stantons Mill, Somerset Co.
Crooked Creek, Rosston and South Bend, Armstrong Co.
Little Mahoning Creek, Goodville, Indiana Co.
Sandy Creek, Sandylake, Mercer Co.
French Creek, Utica, Venango Co.; Cochranton, Meadville, and Cambridge Springs, Crawford Co.
Conneaut Outlet, Conneautlake, Crawford Co.
Conneaut Lake, Crawford Co.
Cussewago Creek, Mosiertown, Crawford Co. (H. & L. Ellsworth).
Leboeuf Creek, Waterford, Erie Co.
Connewango Creek, Russell, Warren Co.
Potato Creek, Smethport, McKean Co. (P. E. Nordgren).

*Monongahela-drainage:*

Monongahela River, Westmoreland Co. (G. A. Ehrmann); Charleroi, Washington Co. (G. A. Ehrmann); Millsboro, Washington Co. (J. A. Shafer).
Dunkard Creek, Wiley, Dunkard, and Mount Morris, Greene Co.[61]
Cheat River, Cheat Haven, Fayette Co.

*Lake Erie-drainage:*

Conneaut Creek, West Springfield, Erie Co.

*Locality in Pennsylvania represented in the Philadelphia Academy of Natural Sciences:*

Ohio River, Beaver, Beaver Co. (S. N. Rhoads).

*Other localities represented in the Carnegie Museum.*

*Lake-drainage:*

Grand River, Cayuga, Haldimand Co., Ontario, Canada (C. Goodrich).
Swan Creek, Toledo, Lucas Co., Ohio (C. Goodrich).
Maumee River, Defiance, Defiance Co., Ohio (C. Goodrich).
Raisin River, Monroe and Grape P. O., Monroe Co., Michigan (C. Goodrich).
Kalamazoo, Kalamazoo Co., Michigan (Hartman collection).

*Ohio-drainage:*

Chautauqua Lake, Chautauqua Co., New York.[62]
Tuscarawas River, Ohio (Holland collection).
West Fork White River, Riverside, Greene Co., Indiana (J. D. Haseman).
Wabash River, Bluffton, Wells Co., Indiana (C. Goodrich); White Co., Illinois (G. H. Clapp, donor).
Ohio River, Congo, Hancock Co., West Virginia; Toronto, Jefferson Co., Ohio; St. Marys, Pleasants Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.
Cheat River, Jaco, Monongalia Co., West Virginia.
West Fork River, Lynch Mines, Harrison Co.; Lightburn and Weston, Lewis Co., West Virginia.
Little Kanawha River, Grantsville, Calhoun Co. (W. F. Graham); Burnsville, Braxton Co., West Virginia.
North Fork Hughes River, Harrisville (W. F. Graham) and Cornwallis, Ritchie Co., West Virginia.
Elk River, Shelton and Clay, Clay Co.; Gassaway and Sutton, Braxton Co., West Virginia.
Pool of Kanawha River, Glen Ferris, Fayette Co., West Virginia.

[61] Dead shells have been seen in Tenmile Creek, Amity, Washington Co.

[62] Particulars about these see below, under var. *sterkii*.

Greenbrier River, Roneeverte, Greenbrier Co., West Virginia.
New River, Hinton, Summers Co., West Virginia; Pearisburg, Giles Co., Virginia.
Reed Creek, Wytheville, Wythe Co., Virginia.
Lieking River, Farmer, Rowan Co., Kentueky.

*Cumberland- and Tennessee-drainage:*

Cumberland River, Orby, Bell Co., Kentueky.
Tennessee River, Tuscumbia, Colbert Co., and Florenee, Lauderdale Co., Alabama (H. H. Smith).
Shoals Creek, Lauderdale Co., Alabama (H. H. Smith).
Elk River, Estill Springs, Franklin Co., Tennessee (H. H. Smith).
Flint River and Hurrieane Creek, Gurley, Madison Co., Alabama (H. E. Wheeler).
Paint Roek River, Paint Roek, Jaekson Co., Alabama (H. H. Smith).
South Chiekamauga Creek, Ringgold, Catoosa Co., Georgia.
Tennessee River, Knoxville, Knox Co., Tennessee.
Freneh Broad River, Boyd Creek, Sevier Co., Tennessee.
Little Pigeon River, Sevierville, Sevier Co., Tennessee.
Holston River, MeMillan and Maseot, Knox Co.; Hodges, Jefferson Co.; Turley Mill, Noeton, and Holston Station, Grainger Co.; Austin Mill and Chureh Hill, Hawkins Co., Tennessee.
South Fork Holston River, Pactolus, Bluff City, and Emmett, Sullivan Co., Tennessee.
Middle Fork Holston River, Chilhowie, Smyth Co., Virginia.
North Fork Holston River, Rotherwood, Hawkins Co., Tennessee; Hilton, Seott Co., Virginia; Mendota, Washington Co., Virginia.
Clineh River, Solway, Knox Co.; Edgemoor, Clinton, and Offutt, Anderson Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Speers Ferry and Clinehport, Seott Co., Virginia; St. Paul, Wise Co.; Fink and Cleveland, Russell Co.; Raven, Riehland, and Cedar Bluff, Tazewell Co., Virginia.
Emory River, Harriman, Roane Co., Tennessee.
Powell River, Combs, Claiborne Co., Tennessee; Dryden, Lee Co., Virginia.
Wallen Creek, Lee Co., Virginia (G. H. Clapp, donor).

*Mississippi and westwards:*

Minnehaha Falls, Minneapolis, Hennepin Co., Minnesota (P. E. Nordgren).
Meramee River, Meramee Highlands, St. Louis Co., Missouri (N. M. Grier).
James River, Galena, Stone Co., Missouri (A. A. Hinkley).
White River, Cotter, Baxter Co., Arkansas (A. A. Hinkley).
Blaek River (H. E. Wheeler), and Spring River (A. A. Hinkley), Blaek Roek, Lawrenee Co., Arkansas.
Saline River, Benton, Saline Co., Arkansas (H. E. Wheeler).[63]
Ouaehita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).[64]
Neosho River, Kansas (R. L. Moodie); Miami, Ottawa Co., Oklahoma (F. B. Isely).
Wea Creek and Bull Creek, Miami Co., Kansas (C. Goodrieh donor) (Osage-drainage).

*Alabama-drainage:* [65]

Buttahatehee River, Hamilton, Marion Co., Alabama (H. H. Smith).
Sipsey River, Elrod, Tusealoosa Co.; Fayette, Fayette Co., Alabama (H. H. Smith).

[63] A peeuliar race, dwarfed, nacre white, inelining toward var. *subgibbosus* (Lea).

[64] Mostly the var. *subgibbosus*, but some are undistinguishable from the normal form. (See Wheeler, 1918.)

[65] Alabama speeimens are largely the var. *subgibbosus*. But the speeimens recorded here are typical *dilatatus* (often intergrading with *subgi' bosus*).

Cahaba River, Gurnee, Shelby Co., Alabama (H. H. Smith).

*Distribution and Ecology in Pennsylvania* (See fig. 10): In the Ohio and Lake-drainage of western Pennsylvania this is, next to *Strophitus edentulus*, the most abundant species. It is practically ubiquitous, and there are few streams, which contain any shells, in which it has not been found. It is moreover common in the large rivers as well as in small creeks, and in some of the latter it is the leading form.

This wide and universal distribution undoubtedly is due to the fact, that this species is not very particular with regard to its station, and it is hardly possible to say that it prefers any definite ecological conditions. It is found in riffles in small streams, as well as among heavy rocks in the larger rivers; it is upon the shell-banks of the Ohio, as well as in quiet pools and eddies with muddy bottom; it is in lakes upon sandy, gravelly, and muddy bottoms. Nevertheless the uniformity of its characters is quite remarkable, and even beyond the limits of Pennsylvania there is hardly any change.

*General distribution: Type locality*; not specifically given by Rafinesque, but Vanatta gives "Kentucky River."

According to Simpson (1900), this species has the following range: "Entire Mississippi-drainage; St. Lawrence and its tributaries; Alabama River system; southeast into Florida; southwest to Guadeloupe River, Texas." However, this includes several varieties.

Typical *E. dilatatus* is certainly found in western New York, occurs in the Kanawha system up to the Bluestone River in West Virginia, and in New River to Virginia (See Call, 1885, and Carnegie Museum). In the Tennessee it extends to northern Alabama, and in the headwaters to southwestern Virginia. Northward it is found in Canada, Michigan, Wisconsin, and Minnesota. Westward it extends to Iowa, Kansas, Oklahoma, and northern Louisiana. In the Alabama system and in southern Arkansas it is largely represented by the form *subgibbosus* (Lea) (See Lewis, 1877). But some specimens from the Cahaba, Black Warrior, and Tombigbee-drainages in the Carnegie Museum, represent the typical phase, while specimens from the Coosa are all *subgibbosus*. Likewise in Arkansas the two forms seem to pass into each other (See Wheeler, 1918).

*E. dilatatus* passes over into the drainage of Lake Michigan and Lake Erie, but, as we shall see below, in Lake Erie proper, it assumes a peculiar form, which is entitled to subspecific rank. In the tributaries of the lake, the typical form is always present.

In western New York, it has been reported from the St. Lawrence-drainage as

well as from the Erie Canal and the Mohawk River (Call) and it belongs to the few species, which have gone along this route probably in very recent times. Whether this stock came from Lake Erie or from the upper Allegheny, remains to be seen.

### ELLIPTIO DILATATUS STERKII Grier (1918).

*Unio gibbosus* BARNES (STERKI, 1907*a*, p. 392) small form; *Unio gibbosus* BARNES (ORTMANN, 1909*b*, p. 203) lake form; *Unio gibbosus* BARNES (WALKER, 1913, p. 22, map, fig. 2 on p. 30); *Elliptio dilatatus sterkii* GRIER, 1918, p. 9.

Plate VIII, fig. 3.

*Records from Pennsylvania:*

Ortmann, 1909*b*, p. 203 (as form of *Unio gibbosus* from Lake Erie).
Grier, 1918, p. 9.

*Characters of variety:* Distinguished from typical *E. dilatatus* by small size, rather swollen shell, (with the diameter over thirty percent, while it is less in the typical form), the more anterior position of the beaks, and lighter color of the epidermis, which is from yellowish olive to brown (sometimes dark brown), with more distinct rays (chiefly when young). Generally in old shells the posterior slope or the posterior end of the shell is lighter in color (yellowish to rusty brown). The growth-rests are rather regular, and rather well-marked by concentric dark bands. Nacre mostly lighter, white to light purple, but sometimes as dark as in the typical form.

| | L. | H. | D. | Pr.ct. |
|---|---|---|---|---|
| *Size:* 1. Erie, Cat. No. 61.3228 (largest) | 87 mm. | 45 mm. | 33 mm. | .38 |
| 2. Erie, Cat. No. 61.4628 (♂) type set | 86 " | 40 " | 33 " | .38 |
| 3. do. do. (♀) do. | 77 " | 37 " | 27 " | .35 |
| 4. do. do. (♀) do. | 72 " | 33 ' | 23 " | .32 |
| 5. do. do. (♂) do. | 58 " | 29 " | 18 " | .31 |

*Soft parts:* They agree entirely with those of typical *dilatatus*. *Glochidia* not known.

*Breeding season:* Gravid females (with eggs) have been observed on July 8 and 12, 1910.

*Remarks:* With a rather large number of specimens (over fifty) before me, I am convinced that this is, as Grier has pointed out, a good local race of *E. dilatatus*. Although the normal form locally does not grow very large, the lake-form is always more swollen (see measurements), and this gives to the shell a rather subcylindrical shape, chiefly so in its anterior part. In the color of the epidermis, young specimens of *sterkii* are distinctly lighter than normal *dilatatus*, and in consequence of

this, the rays are better visible, and the growth-rests become more marked. When older the epidermis becomes darker, and may be even blackish, but in many old specimens it remains light, chiefly so at or near the posterior end. This part of the shell is often covered with a growth of other organisms. The regularity of the growth-rests is rather variable, but in well-developed specimens it is quite striking. In shape young specimens are more like normal *dilatatus*. In fact sometimes they are indistinguishable except by the color.

*Localities represented in the Carnegie Museum:*

Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania (type locality).

Lake Erie, off North shore of Presque Isle, Erie, Erie Co., Pennsylvania (depth 10 feet).

Lake Erie, Cedar Point, Erie Co., Ohio (C. Brookover); La Plaisance Bay, Monroe Co., Michigan (C. Goodrich); Port Colborne, Welland Co., Ontario, Canada (C. Goodrich).

*Distribution and Ecology* (See fig. 10 and Walker, 1913, fig. 2, p. 30): *Type locality:* Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania. *Type set:* Carnegie Museum Cat. No. 61.4628 (not 4268, as Grier states!).

This form is exclusively known from Lake Erie. According to my observations it lives in Presque Isle Bay, preferably along the North shore of the bay, in the characteristic fine sand, in from one to five feet of water, and chiefly at the edge or within the *Juncus americanus* formation (among "rushes"). It also is frequently found among *Chara* patches. However, I also found it on the south shore of the bay in gravel and shingle, and one specimen was obtained by the "sand-sucker" in the open lake, in about ten feet of water.

Sterki (1907*a*, p. 392) and Walker (1913, p. 22) are the only authors, who previously have mentioned this form from Lake Erie, but without separating it from the main form. Grier (1918) first recognized it as a variety.

*Note:* It is interesting to compare specimens obtained under similar ecological conditions at other localities. A very remarkable form is *E. dilatatus* from Chautauqua Lake, Chautauqua Co., New York. I have eighteen specimens collected by various parties at Bemus Point and Celeron. This is a form distinctly inclining towards the var. *sterkii*. It is rather small (longest 79 mm.), is also slightly more swollen than the true *dilatatus*, and has the beaks a little more anterior; but with regard to color, the Chautauqua form does not differ from *dilatatus*. This is, of course, no intergrade (genetically), but has developed independently, coming up into Lake Chautauqua from the upper Allegheny.

In Conneaut Lake, Crawford Co., Pennsylvania, a form of *E. dilatatus* exists, which is not at all different from the normal one, except that it is rather small. It is rare in this lake, but more abundant in the outlet, and assumes, in French Creek, to which the outlet flows, the typical size.

The only tributary of Lake Erie in Pennsylvania, Conneaut Creek, contains a small race of typical *E. dilatatus*. There are no indications, that this has come up from the lake. It may as well have crossed over from the Beaver or French Creek drainages.

Of course *E. dilatatus sterkii* must have come into the lake from the Ohio system, and the Wabash-Maumee route is the first to be considered (See Walker, 1913), but it may have crossed elsewhere, since the typical form ascends in many places far into the headwaters. The remarkable thing is that in all tributaries of the lake the normal *dilatatus* is present, in Michigan at Ann Arbor), Marshall, 1895) in Ohio in the Cuyahoga (Dean, 1890) in Indiana in the drainage of the Maumee, St. Marys, and St. Josephs Rivers (Call, 1900). Call mentions the fact that there is in the lakes of northern Indiana, a form which is flatter and thinner. This, of course, would not lead to *sterkii*.

### Elliptio violaceus (Spengler) (1793).

*Unio violaceus* Spengler. Haas, 1913, p. 54, text-fig. 2; *Unio complanatus* (Dillwyn) Simpson, 1914, p. 651.

Plate VIII, figs. 4, 5.

*Records from Pennsylvania:*

Say, 1817 (Delaware and Schuylkill Rivers) as *purpureus* (See Binney, 1858).
Haldeman, 1844 (Lancaster Co.).
Lea, Obs. IV, 1848 (Cobbs Creek, La Grange, near Philadelphia) (*fuliginosus*).[66]
Gabb, 1861 (League Island and Schuylkill River, Philadelphia).
Bruckhart, 1869 (Lancaster Co.).
Hartman & Michener, 1874 (Chester Co.).
Schick, 1895 (Delaware and Schuylkill Rivers, Corinthian Reservoir, Philadelphia; Canal at Manayunk, Philadelphia Co.; Munckinipattus Creek, Glenolden, Delaware Co.).
Ortmann, 1909*b*, p. 208.
Caffrey, 1911 (Lehigh and Delaware Rivers, Northampton Co.).

*Characters of the shell:* Shell moderately large and moderately heavy. Outline subtrapezoidal, more or less elongate, generally almost twice as long as high, or even longer. Anterior end rounded, posterior end slightly produced and slightly pointed; lower margin more or less convex, often nearly straight. Upper margin subparallel to the lower margin, forming an angle with the obliquely descending posterior margin. Beaks not prominent, at variable distance from the anterior end, but not close to it. Beak-sculpture distinct, consisting of five to six ridges, the first two or three curved and subconcentric, those following running in the

[66] Cobbs Creek is a branch of Darby Creek, near Essington, Philadelphia County.

direction of the growth-lines, being subparallel and nearly straight in the middle, and curving up in front and behind, the posterior curve being angular, with a slight swelling (See Marshall, 1890, fig. 6). Shell not, or very little, swollen, generally more or less compressed, chiefly so on the posterior slope, with a blunt, more or less distinct posterior ridge. Sides of the disk generally flat. Surface without sculpture.

Epidermis yellowish, to brown and blackish. In young specimens, more or less distinct greenish rays are present. The epidermis rarely is lighter and greenish in color, with more distinct rays. The latter are capillary or somewhat broader, straight. In older shells, all traces of rays generally disappear. Growth-rests more or less strongly marked, but often quite indistinct.

Hinge-teeth well-developed, but not very heavy. Pseudocardinals divergent, ragged. Interdentum practically absent. Lateral teeth long, gently curved. Beak-cavity very shallow. Dorsal muscle-scars in the beak-cavity. Nacre white or colored, with an immense range of variation, through all shades of salmon, pink, red, purple, and blueish, with coppery or bronze lustre or iridescence; often whitish with lurid tints (greenish and grayish, as if discolored).

No sexual differences in the shell.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Flinton, Cat. No. 61.3797 (largest from Pennsylvania) | 120 mm. | 65 mm. | 32 mm. |
| 2. Tioga, Cat. No. 61.4312 | 110 " | 57 " | 25 " |
| 3. Selinsgrove, Cat. No. 61.4643 | 100 " | 58 " | 35 " |
| 4. Manayunk, Cat. No. 61.1832 | 88 " | 47 " | 27 " |

*Soft parts* (See Ortmann, 1912, p. 269). *Glochidia: ibid.*, Pl. 19, fig. 1.

*Breeding season:* For gravid females the following dates are at hand: April 26, 1909; May 3, 1909; May 4, 1909; May 6, 1912; May 9, 1911; May 10, 1912; May 11, 1912; June 3, 1912; June 4, 1912; June 5, 1912; June 7, 1912; June 10, 1912; June 12, 1912; June 13, 1912; June 14, 1910; July 9, 1914; July 11, 1914; July 16, 1908. Glochidia have been found as early as June 7, and discharging females have been observed on June 7 and 13, and July 9 and 11. According to these dates this is a tachytictic form, breeding from the end of April to July, but the season may extend to August, as Conner (1907, p. 88) states. The discharging females expelled their placentæ whole into the surrounding water.

*Remarks:* This species is quite characteristic and easily recognized, in spite of its immense range of variation. The trapezoidal outline (with the upper and posterior margins forming an angle), and the flat sides of the shell are reliable features, and in most cases the shell is distinctly compressed. If more swollen,

the greatest width is situated in the region of the posterior ridge, but not in the anterior part of the shell, as in *E. dilatatus*. This anterior swelling, and the tapering posterior end of the shell, distinguish this latter species from *E. violaceus*.

In other respects *E. violaceus* is extremely variable. First of all in size and shape (longer or shorter), then in the degree of compression (compare our measurements). Furthermore the color of the outside and of the nacre is variable, and finally the epidermis may be more or less smooth, or may be roughened by concentric lamellæ. Since the shell is not very particular as to station (see below), it is not astonishing that the responses to the environment are numerous, and that it assumes in many places peculiar features, which, however, are not at all constant, and may turn up anywhere under proper conditions, and are connected by innumerable intergrades. There is no tendency in Pennsylvania to develop local races or varieties, and I am perfectly satisfied that there is only *one* species in our region.

"Species-making" within this form has gone beyond all bounds, and in a large number of Lea's "species," chiefly from the southern states, the question may be raised whether Lea was actually in earnest, when proposing them, or whether he only wanted to mystify contemporaneous and subsequent students of naiadology. Great credit is due to Simpson for straightening out the worst of this tangle; but I think that Simpson has not gone far enough. I shall mention here a few additional instances of species created by Lea, which in my opinion simply fall as synonyms under *E. violaceus*, merely representing individual phases. This chiefly concerns such forms as are actually found in our state.

*Unio complanatus jejunus* (Lea): Simpson (1914, p. 658) unites *jejunus* and *percoarctatus* Lea, and makes this a variety of the present species. Both are southern types (from the Carolinas), and both are said to be more compressed, while *jejunus* is reported to have an inclination to be biangulate behind, and *percoarctatus* is said to have the surface covered with loose concentric striæ. All these characters are found in the Pennsylvanian *E. violaceus* in certain individuals. They may be very much compressed, they have very often a tendency to be biangulate behind, and they have often a rough epidermis, with loose striæ. I have specimens, which completely agree with *jejunus*, as well as with *percoarctatus*, and sometimes such specimens (See Plate VIII, fig. 5) prevail at certain localities, but they are always connected with the normal form by intergrades.

*Unio roanokensis* Lea, and *northamptonensis* Lea: Simpson (1914, p. 666) regards these as one species, distinct from our species. The form *northamptonensis* is reported from as far north as Massachusetts, and might be expected in Penn-

sylvania. Both shells are described as being large, flat, biangulate behind, while *northamptonensis* is said (Simpson, 1900, p. 728 *footnote*) to have in addition the posterior point elevated above the base line. Such shells may be found anywhere in Pennsylvania. Specimens from Hartford, Connecticut, one of the type localities of *northamptonensis*, and which are in the Carnegie Museum, are in fact normal, large representatives of *E. violaceus*.

*Unio fuliginosus* Lea. This shell from Cobbs Creek, near Philadelphia, is quoted twice by Simpson in 1900, first (p. 722) as synonym of *complanatus*, then

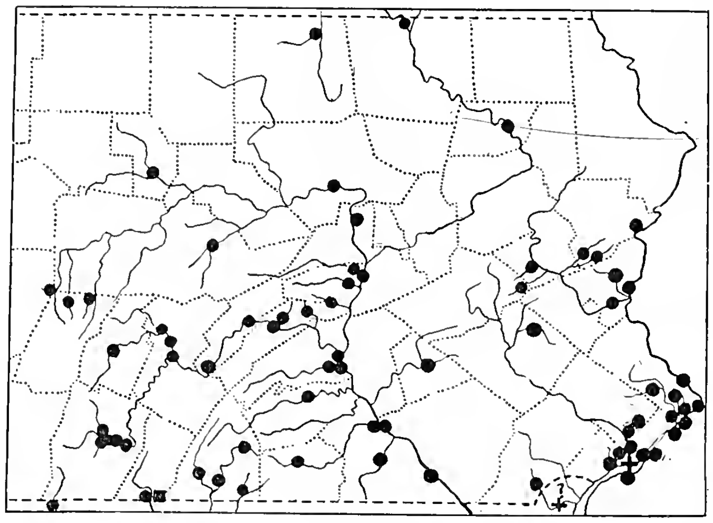

FIG. 11.

● *Elliptis violaceus.*
■ *Elliptis cupreus.*
+ *Elliptis fisherianus.*

(p. 727) as of *icterinus* Conrad; but in 1914 (p. 665) only the latter reference is given. I do not know *icterinus*, which is southern. The *fuliginosus* Lea, however, does not agree with the original description of *icterinus* (Conrad, Mon. 4, 1836, Pl. 18, fig. 2), and I think, the first reference of Simpson is correct, and the Pennsylvanian *fuliginosus* is identical with *E. violaceus*.

*Localities in Pennsylvania represented in the Carnegie Museum:*

*Delaware-drainage:*

Delaware River, Penns Manor and Yardley, Bucks Co.; Shawnee, Monroe Co.
White Clay Creek, Avondale, Chester Co.
Schuylkill Canal, Manayunk, Philadelphia Co.
Wissahickon Creek, Flourtown, Montgomery Co. (P. A. Keppelmann).
Little Neshaminy Creek, Grenoble, Bucks Co.
Common Creek, Tullytown, Bucks Co.
Princess Creek, Kunkletown, Monroe Co.

Meniolagomeka Creek, Smith Gap, Monroe Co.
Lizard Creek, Mantz and West Penn, Schuylkill Co.
Mahoning Creek, Lehighton, Carbon Co.

*Susquehanna-drainage:*

Susquehanna River, York Furnace and York Haven, York Co.; Duncannon, Perry Co.; Selinsgrove, Snyder Co.
Codorus Creek, York, York Co.
Conewago Creek, York Haven, York Co.; Table Rock, Adams Co.
Conodoguinet Creek, Carlisle, Cumberland Co.
Shermans Creek, Duncannon, Perry Co.
Juniata River, Juniata Bridge, Perry Co.; Lewistown, Mifflin Co.
Canal, Mifflintown, Juniata Co. (D. A. Atkinson).
Lost Creek, Mifflintown, Juniata Co. (D. A. Atkinson).
Cocolamus Creek, Cocolamus, Juniata Co. (D. A. Atkinson).
Raystown Branch Juniata River, Ardenheim, Huntingdon Co.; Everett and Mount Dallas, Bedford Co.; Lutzville, Bedford Co. (J. F. L. Raschen); Dunning Creek, Bedford, Bedford Co. (J. F. L. Raschen); Shobers Run, Bedford Springs, Bedford Co. (A. Koenig).
Frankstown Branch Juniata River, Huntingdon and Alexandria, Huntingdon Co. (D. A. Atkinson); Hollidaysburg, Blair Co.
West Branch Mahantango Creek, Richfield, Juniata Co. (D. A. Atkinson).
Middle Creek, Freeburg, Snyder Co. (D. A. Atkinson).
Penns Creek, Selinsgrove, Snyder Co.
Canal, Watsontown, Northumberland Co. (D. A. Atkinson).
West Branch Susquehanna River, Williamsport, Lycoming Co. (D. A. Atkinson).
Bald Eagle Creek, Milesburg, Center Co.
Driftwood Branch Sinnamahoning Creek, Driftwood, Cameron Co.
Beaver Dam Creek, Flinton, Cambria Co. (D. A. Atkinson).
Chest Creek, Patton, Cambria Co.
Cush Cushion Creek, Green Township, Indiana Co. (D. A. Atkinson).
North Branch Susquehanna River, Tunkhannock, Wyoming Co.
Chemung River, South Waverly, Bradford Co.
Millrace of Crooked Creek, Tioga, Tioga Co.

*Potomac-drainage:*

East Branch Little Antietam Creek, Waynesboro, Franklin Co.
Conococheague Creek, Greencastle and Scotland, Franklin Co.
West Branch Conococheague Creek, Mercersburg Junction, Franklin Co.
Great Tonoloway Creek, Thompson Township, Fulton Co.

*Localities in Pennsylvania represented in the Philadelphia Academy of Natural Sciences:*

Sacony Creek, Kutztown, Berks Co. (H. K. Deisher).
Big Neshaminy Creek, "Edderton,"[67] Bucks Co. (H. W. Fowler).
"Guinea Creek,"[68] Woodbournè, Bucks Co. (H. W. Fowler).

[67] Probably *Eddington.*

[68] No creek of this name occurs on the map of the U. S. Topographic Survey (Sheet Burlington). The creek at Woodbourne is a branch of Mill Creek.

Bushkill Creek, Belfast, Northampton Co. (H. W. Fowler).
Susquehanna River, York Furnace, York Co. (W. Stone).
Little Swatara Creek, Jonestown, Lebanon Co. (W. H. Zehring) (C. H. Conner).
Juniata River, Newton-Hamilton, Mifflin Co. (H. T. Mather, Jr.).

*Localities on the New Jersey side of the Delaware in the Philadelphia Academy of Natural Sciences:*

Delaware River, Washington Park, near Newbold, Gloucester Co. (C. H. Conner); Delanco, Burlington Co. (H. A. Pilsbry); Burlington Island, Burlington Co. (H. W. Fowler).

*Other localities represented in the Carnegie Museum:* [69]

*St. Lawrence-drainage:*

Spider Bay of Georgian Bay, Sans Souci, Parry Sound Co., Ontario, Canada (H. Kahl).
Muskoka Lake, Bala, Muskoka Co., Ontario, Canada (A. S. Daggette).
Severn River, Gloucester Pool, Muskoka Co., Ontario, Canada (O. A. Peterson).
Pigeon Lake, Bobcaygeon, Victoria Co., Ontario, Canada (G. H. Clapp).
Sandy Lake, Peterboro Co., Ontario, Canada (G. H. Clapp).
St. Lawrence River, Montreal, Quebec, Canada (Hartman collection); Bluff Island and Grindstone Island, near Clayton, Jefferson Co., New York (Miss A. H. Robinson) (H. Kahl).
Lake Ontario, Hamilton Bay, Wentworth Co., Ontario, Canada (Miss R. Buchert); Braddock Bay, Manitou Beach, Monroe Co., and Sodus Point, Wayne Co., New York (R. H. Santens).
Genesee River, Rochester, Monroe Co., New York (R. H. Santens).
Lake Champlain, New York (Hartman collection).

*New England:*

Fish River, Eagle Lake, Square Lake, and Cross Lake, Aroostook Co., Maine (O. O. Nylander).
Little Madawaska River, Westmoreland, Aroostook Co., Maine (O. O. Nylander).
Piscataquis Co., Maine (C. Goodrich, donor).
Otisfield, Cumberland Co., Maine (G. H. Clapp, donor).
Lilly Lake, Pittsfield, Merrimack Co., New Hampshire (Mrs. L. D. Thompson, donor).
Shawsheen River, Bedford, Middlesex Co., Massachusetts (Mrs. L. D. Thompson).
Haughtons Pond, Blue Hills, Norfolk Co., Massachusetts (Mrs. L. D. Thompson, donor).
Connecticut River, Hartford, Hartford Co., Connecticut (Hartman collection).

*New York and New Jersey:*

North Branch Susquehanna River, Binghamton, Broome Co., New York (H. H. Smith).
Culvers Pond, Sussex Co., New Jersey (J. F. L. Raschen).
Stony Brook and Delaware-Raritan Canal, Princeton, Mercer Co., New Jersey.
Delaware River, Fish House, Camden Co., New Jersey.

[69] Only those are given for which I either can vouch personally, or which are from reliable sources. The Carnegie Museum possesses many more, chiefly from the southern states, which may be correct or wrong, and which are referred to various species of Lea, which cannot properly be identified at present. Specimens from Catawba River, Bridgewater, Burke Co., North Carolina, collected by myself, correspond well with *U. percoarctatus* Lea, which is from the same river in Gaston Co. a little lower down. No typical *E. violaceus* was met with here, but associated with it is a form appearing quite distinct, but which I have been unable to identify. Walker, to whom I have sent specimens, did not wish to express an opinion in regard to them.

Barton Run, below Tomlisons Mill (= Jennings Mill), Marlton, Burlington Co., New Jersey (C. H. Conner).[70]

*Potomac-drainage:*

Potomac River, Cabin John, Montgomery Co., Maryland (J. D. Haseman); Hancock, Washington Co., Maryland; Cherry Run, Morgan Co., West Virginia.

Wills Creek, Ellerslie, Allegheny Co., Maryland.

South Branch Potomac River, Southbranch and Romney, Hampshire Co., West Virginia.

Shenandoah River, Harpers Ferry, Jefferson Co., West Virginia.

North Fork Shenandoah River, Broadway, Rockingham Co., Virginia.

South Fork Shenandoah River, Elkton, Rockingham Co., Virginia.

South River, Waynesboro, Augusta Co., Virginia.

*Southern localities:*

Rappahannock River and Marsh Run, Remington, Fauquier Co., Virginia.

Mountain Run, Culpeper, Culpeper Co., Virginia.

Rapidan River, Rapidan, Culpeper Co., Virginia.

North River, Lexington, Rockbridge Co., Virginia.

Calf Pasture River, Goshen, Rockbridge Co., Virginia.

Jackson River, Covington, Allegheny Co., Virginia.

Roanoke River, Salem, Roanoke Co., Virginia.

Tinker Creek, Roanoke, Roanoke Co., Virginia.

Mason Creek, Salem, Roanoke Co., Virginia.

*Distribution and Ecology in Pennsylvania* (See fig. 11): This is the commonest form of Naiades in the Atlantic-drainage in Pennsylvania, and is as characteristic and as abundant on the eastern side of the Alleghenian divide, as is *E. dilatatus* on the western, in fact, it is even more universally distributed than the latter. (Ortmann, 1913*a*, pp. 361, 362). It apparently has no ecological preferences, being found practically in any permanent body of water; in canals and reservoirs with quiet water and muddy bottom, as well as in large rivers with strong current and heavy gravel and rocks. In the small creeks it goes up very far into the headwaters, and is found, for instance, in the small tributaries of the West Branch of the Susquehanna, close to the divide as in Cush Cushion Creek in Indiana County. Here it is only about twenty miles away from the nearest locality of *E. dilatatus* in the Allegheny-drainage in Indiana County. (Yellow and Little Mahoning Creeks.) Also in Virginia, similar observations have been made (See Ortmann, 1913*a*). In the region, where the headwaters of New River and those of the James and Roanoke Rivers come together, the two species are found immediately west and east of the divide.

The ability of *E. violaceus* to live everywhere under a great variety of environmental conditions undoubtedly accounts for its great variability, as well as its

[70] Quite a peculiar form, unusually swollen, with white nacre, which requires further investigation.

tendency to develop many different phases, which may turn up anywhere under proper conditions, but which do not lead to the development of geographical races, at least in our territory.

*General distribution: Type locality,* North America (Spengler).

According to Simpson (1900, p. 725), *E. violaceus* is found on the Atlantic side from the St. Lawrence to Georgia. The southern boundary is extremely uncertain, and is obscured by a great development of local forms, the standing of which is very doubtful.[71] Northward, it goes to Maine (Jackson, 1908, Lermond, 1909, Nylander, 1914), and, according to Call, to Nova Scotia. From the lower St. Lawrence-drainage, it has been reported from many localities in Vermont, New York, and Canada, up to and into Lake Ontario. It has never been found in Lake Erie, but turns up again in the upper lakes district, in western Ontario (see our localities in Sandy and Pigeon Lakes, and in Muskoka and Parry Sound Cos.). It has been discovered in various places in northern Michigan, as far as Lake Superior (See Walker, 1898, p. 5; 1913, map on p. 30, and Winslow, 1917, p. 11). An isolated locality is the one reported by Sterki (1907*a*, p. 393) from a mill-race at New Philadelphia, Tuscarawas Co., Ohio, and recently I found a single specimen in Grand River, Eagleville, Ashtabula Co., Ohio.

This westward extension of the range apparently was not by way of Lake Erie, but from the lower St. Lawrence, in the region about Ottawa, in the direct line toward Lake Huron, so that in Michigan it is a recent immigrant from the North. Walker (1913) has treated this question in detail: the migration was by way of the Trent or Nipissing route (*l. c.*, pp. 44, 45, fig. 4).

The established range of this species is unique, and larger than that of any other form of the Atlantic slope. Most peculiar is the westward extension in the north. There is only one species, which might be compared with this, *Eurynia nasuta*, but the range of this from west to east goes by way of Lake Erie, and is undoubtedly governed by different laws, as I have shown (Ortmann, 1913*a*, pp. 378 ff.).

### Elliptio cupreus (Rafinesque) (1820).

*Unio productus* Conrad. Simpson, 1914, p. 690.[72]

Plate VIII, fig. 6.

*Records from Pennsylvania:*

Ortmann, 1910, p. 117 (Fulton Co.).

[71] Conrad (1834, p. 8) says that the shells of the type of *U. purpureus* (= *E. violaceus*) are in the Savannah, Oconee, and Ocmulgee Rivers, and also in Flint River, Georgia, but that to the west of this he did not find them.

[72] *U. fisherianus* Reeve (1865, Pl. 24, fig. 113) is not *U. fisherianus* of Lea, but clearly the present species.

*Characters of the shell:* Shell rather small and not heavy. Outline elongated trapezoidal, or elongated ovate, lance-head shaped, a little over twice as long as high. Greatest height of the shell about in the middle at the ligament (mostly height of shell about the same from the beaks to the end of the ligament). Anterior end rounded, posterior end tapering and bluntly pointed. Lower margin more or less curved, but often almost straight in the middle. Upper margin straight or somewhat curved, nearly parallel to the lower margin, and forming a more or less distinct angle with the upper posterior margin. Beaks not prominent, placed rather anteriorly, but at a certain distance from the anterior end. Beak-sculpture identical with that of *E. violaceus*, but sometimes the straight portion of the bars, in their middle part, is slightly and indistinctly sinuated. Shell not swollen, more or less compressed, with the sides of the disk rather flat. A rounded, indistinct posterior ridge is present. Surface without sculpture.

Epidermis greenish olive, brownish olive, yellowish brown to brown, or even blackish. Young specimens sometimes with rather indistinct, greenish rays, of the same character as those of *E. violaceus*, but in most cases no traces of rays are visible. Growth-rests generally not marked off by darker color.

Hinge-teeth well-developed, but not very strong, of the general character of those of *E. violaceus*. Beak-cavity shallow. Dorsal muscle-scars in the beak-cavity. Nacre whitish, lurid, or of some shade of red or purple, lighter or darker, often with coppery iridescence.

No sexual differences in the shell.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Romney, Cat. No. 61.5898 (extralimital) | 88 mm. | 38 mm. | 23 mm. |
| 2. Fulton Co., Cat. No. 61.4323 (largest from Pa.) | 70 " | 30 " | 15 " |
| 3. do. do. | 66 " | 30 " | 16 " |
| 4. do. do. | 60 " | 27 " | 16 " |
| 5. do. do. | 49 " | 23 " | 11 " |

*Soft parts* (See Ortmann, 1912, p. 270). Gravid females have subsequently been found, and the structure of the marsupium agrees fully with that of *E. violaceus*. *Glochidia:* L. 0.20, H. 0.20 mm., similar in shape to those of *E. violaceus* (which are 0.20 × 0.19 mm.).

*Breeding season:* Gravid females were found on May 6, 1912; June 3, 1912; June 4, 1912; June 7, 1912; June 8, 1912. All these were from the Potomac, Rappahannock, and James drainages, outside of Pennsylvania. At the earliest date, glochidia in some individuals were already present.

*Remarks: Obliquaria cuprea* Rafinesque (1820, p. 304) is this species, as is evident from the description, the very poor (exaggerated) figure, and the comparison

with *U. nasuta* Say. Rafinesque gives the Monongahela and Potomac Rivers as habitats, but the first locality apparently is an error. (On p. 294 Rafinesque describes a *Unio fasciata cuprea,* but this does not conflict with *Obliquaria cuprea*).

This species is allied to the type of *E. violaceus,* but differs in its extreme elongation and lanceolate shape. The subtrapezoidal outline is obscured, but at least in young specimens is indicated by the presence of an angle between the upper and the posterior margins. It is hardly possible to confuse this species with *E. violaceus,* but it has a much closer resemblance to the following (*E. fisherianus*), and has been mixed up with this by various writers. It is possible that *E. fisherianus* is merely a variety of *E. cupreus.* There are other "species" in the southern states, which group with this form, but they require further study.

This shell (as well as *E. fisherianus*) has an outward resemblance to *Eurynia nasuta* (Say), and was supposed to be nearly allied to it by the earlier authors, but the anatomical structure is entirely different.

*Localities represented in the Carnegie Museum:*

Great Tonoloway Creek, Thompson Township, Fulton Co., Pennsylvania.
Potomac River, Hancock, Washington Co., Maryland.
South Branch Potomac River, Southbranch and Romney, Hampshire Co., West Virginia.
Rappahannock River, Virginia (G. H. Clapp, donor).
Marsh Run, Remington, Fauquier Co., Virginia.
Mountain Run, Culpeper, Culpeper Co., Virginia.
North River, Buena Vista and Lexington, Rockbridge Co., Virginia.
Calf Pasture River, Goshen, Rockbridge Co., Virginia.
Jackson River, Covington, Alleghany Co., Virginia.

*Locality represented in the Philadelphia Academy of Natural Sciences:*

Shenandoah River, Harpers Ferry, Jefferson Co., West Virginia (G. W. Tryon, Jr.).

*Distribution and Ecology* (See fig. 11): *Type-locality,* Potomac River (Rafinesque).

Conrad's *Unio productus,* which undoubtedly is this species, is given from the Savannah River, Augusta, Richmond Co., Georgia. But Simpson (1900, p. 735) mentions only North Carolina, Virginia, and Maryland. But later (1914, p. 691) he adds the type-locality. The southward range of this species as yet remains obscure, and furthermore very few exact localities are on record. Besides those given by myself, I know of only one which is reliable, that furnished by Pilsbry (1894) from Sideling Creek, Allegany Co., Maryland.[73]

[73] As I have suggested elsewhere (Ortmann, 1913*a*, p. 320), Conrad's *Unio lanceolatus* (1846) from the Upper James-drainage, is probably this species.

I have located this species in the drainages of the Potomac, Rappahannock, and James, in Maryland, Virginia, and eastern West Virginia, and also in a northern tributary of the Potomac (Great Tonoloway Creek) in southern Pennsylvania, just North of the Mason and Dixon line. I have hunted for this species in other tributaries of the Potomac in Pennsylvania, in Antietam and Conococheague Creeks, but failed to find the slightest trace of it.

Where I collected this form, it is not at all rare. I found it either in gravel, or among larger rocks, in mud-filled interstices, but generally not in strong current, but in quiet coves and eddies. It also seems to prefer the smaller streams to the larger rivers.

With the exception of the Rappahannock, I never found it East of the Blue Ridge, on the Piedmont Plateau or Coastal Plain, but it should be expected to be more frequent there. The relation of its distribution to that of the next species (*E. fisherianus*) should be ascertained.

### ELLIPTIO FISHERIANUS (Lea) (1838).

*Unio fisherianus* LEA. SIMPSON, 1914, p. 692.

Plate VIII, fig. 7.

*Records from Pennsylvania:*

Gabb, 1861 (Schuylkill River, above Girard Bridge, Philadelphia).
? Hartman & Michener, 1874 (White Clay Creek, Chester Co.) (see below).

*Characters of the shell:* Very close to *E. cupreus*, and differing chiefly by somewhat larger size, slightly more elongated shape, and greater taper in the posterior part of the shell. The greatest height of the shell is situated more anteriorly, at about the beaks, and from this part the shell decreases in height to the posterior end. At the same time the posterior end is more elevated, so that the posterior ridge is not straight, but curves up slightly behind, and the lower margin also is more curved. In all other characters this form agrees with *E. cupreus*. The epidermis is more greenish blackish, the nacre white to purple.

| | | | L. | H. | D. |
|---|---|---|---|---|---|
| *Size:* 1. Kent Co., Del., Cat. No. 61.4645 | | .............. | 106 mm. | 40 mm. | 26 mm. |
| 2. do. | do. | .............. | 88 " | 35 " | 23 " |
| 3. do. | do. | .............. | 73 " | 27 " | 19 " |
| 4. do. | do. | .............. | 57 " | 22 " | 14 " |

*Soft parts, glochidia,* and *breeding season* unknown.

*Remarks:* According to the material at hand, this species stands very close to *E. cupreus*, and it possibly is only a local race (lowland form) of it. However

intergrades have not been observed, but may exist in the lower parts of the rivers. Attention should be paid to this question.

*Localities represented in the Carnegie Museum:*

Mill-pond of Ratcliff Creek, Chestertown, Kent Co., Maryland (E. G. Vanatta).
Choptank Mills, Kent Co., Delaware (S. N. Rhoads).

*Localities represented in the Philadelphia Academy of Natural Sciences:*

Church Hill, Queen Anne Co., Maryland (E. G. Vanatta).
Potomac River, Washington, D. C. (G. W. Tryon, Jr.) (John Ford).

*Distribution and Ecology* (See fig. 11): *Type locality,* Head of Chester River, Maryland (Lea).

Simpson reports this species from: "Virginia, Maryland, Pennsylvania," and Rhoads (1904) from two localities in Delaware.[74] There is no doubt that "Pennsylvania" is founded upon the records mentioned above (Gabb, and Hartman & Michener). Gabb reports only a single specimen from his locality, the lower Schuylkill River, and since this evidently offers the necessary conditions, there is no reason to doubt the fact that the species has occurred there. However, I entertain strong doubts that this species ever existed in White Clay Creek in Pennsylvania. I have been at White Clay Creek, at Avondale, Chester Co., Pennsylvania, and here it is an upland stream, and does not at all present the conditions, which I regard as being favorable for this species. It is possible that Hartman & Michener found this species farther down in this creek, in the lowlands of the state of Delaware, but not in Pennsylvania.[75]

The evidence for the existence of this species in Pennsylvania rests upon the single individual reported by Gabb. It is not impossible that it may be found again, and the chance to rediscover it will be in or near the estuary of the Delaware, for according to the records at hand this species seems to prefer the Coastal Plain, living in slowly running rivers, ponds, or similar stations; it is a lowland form, as I have pointed out elsewhere (Ortmann, 1913*a*, p. 361).

## Subfamily ANODONTINÆ (Swainson) Ortmann (1910).

Ortmann, 1910, p. 117; 1911*b*, p. 336; 1912, p. 224.

### Key to the Genera of the Anodontinæ.

$a_1$. Beak-sculpture double-looped, with a sharp reëntering angle or a sinuation. Mantle connection between anal and supra-anal openings moderate or very long. No tendency to unite the inner lamina of the inner gills with abdominal sac.

[74] In addition to the above locality: Seaford, Sussex Co., Delaware.

[75] The Carnegie Museum acquired in the Hartman collection a single set of this species, but there is no indication that it came from our state.

$b_1$. Hinge-teeth more or less well-developed, at least the pseudocardinals present. Shell generally not very thin. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Lasmigona.*

$b_2$. Hinge-teeth completely absent. Shell thin, generally very thin. . . . . . . . . . . . . *Anodonta.*

$a_2$. Beak-sculpture concentric. Mantle connection between anal and supra-anal openings moderate. Sometimes a tendency to unite the inner lamina of the inner gills with the abdominal sac.

$b_1$. Beak-sculpture fine. Hinge-teeth practically absent. . . . . . . . . . . . . *Anodontoides.*

$b_2$. Beak-sculpture heavy, often very heavy. Hinge-teeth more or less developed or rudimentary.

$c_1$. Hinge complete, or at least the pseudocardinals present. Marsupium with simple ovisacs. *Alasmidonta.*

$c_2$. Hinge-teeth rudimentary, but slight traces of pseudocardinals present. Marsupium with the ovisacs subdivided into transverse compartments. . . . . . . . . . . *Strophitus.*

## Genus Lasmigona Rafinesque (1831).

*Symphynota* Ortmann, 1912, p. 280; *Symphynota*, Simpson, 1914, p. 480; *Lasmigona* Frierson, 1914*b*, p. 40.

Type *Alasmidonta costata* Rafinesque.

Simpson has divided this genus into three subgenera, and Ortmann (1914, p. 41) has added others, but the latter are extralimital. The nomenclature of the genus and the subgenera has been revised in this paper in accordance with Frierson (1914*b*, p. 40) and Walker (1918).

Key to the Subgenera of Lasmigona.

$a_1$. Lateral hinge-teeth present. Shell smooth. Beak-sculpture double-looped. Hermaphroditic. Subgenus *Platynaias.*

$a_2$. Lateral hinge-teeth obliterated. Shell smooth, or with ribs upon the posterior slope. Gonochoristic.

$b_1$. Shell subrhomboidal or subelongate. Posterior slope with ribs. Beak-sculpture indistinctly double-looped. . . . . . . . . . . . . . . . . . . . . . . . . . . Subgenus *Lasmigona.*

$b_2$. Shell broadly ovate-rhomboidal, not elongated, with high posterior wing. Posterior slope with ribs, which may be obliterated. Beak-sculpture sharply double-looped. . . Subgenus *Pterosyna.*

## Subgenus Platynaias Walker (1918).

*Symphynota* Simpson, 1914, p. 481; Ortmann, 1914, p. 42; *Platynaias* Walker, 1918, p. 2.

Type *Unio viridis* Rafinesque.

Two species belong to this subgenus, which may be distinguished as follows.

Key to the Species of the Subgenus Platynaias.

$a_1$. Shell moderately large, subsolid, compressed. Outline more or less rhomboidal; western habitat. *L.* (*P.*) *viridis.*

$a_2$. Shell small, thin, not so much compressed. Outline rather subovate; eastern habitat. *L.* (*P.*) *subviridis.*

### Lasmigona (Platynaias) viridis (Rafinesque) (1820).

*Symphynota compressa* Lea. Simpson, 1914, p. 481; *Lasmigona viridis* (Rafinesque) Frierson, 1915, p. 59.

Plate IX, figs. 1, 2.

*Records from Pennsylvania:*

Rhoads, 1899 (Beaver River, Wampum, Lawrence Co.).
Ortmann, 1909*b*, p. 196, 202.

*Characters of the shell:* Moderately large, subsolid, but not very heavy. Outline subrhomboidal, or subtrapezoidal, longer than high. Anterior end rounded, posterior subtruncate. Lower margin slightly convex; upper margin straight, more or less ascending and elevated posteriorly, forming a more or less distinct wing at the upper posterior angle. In young shells the upper posterior margin is symphynote. Beaks not prominent, placed in front of the middle of the shell. Beak-sculpture distinct, consisting of about five bars, of which the first or the two first are subconcentric, while those following are distinctly double-looped, with the anterior loop rounded, the posterior angular, and slightly narrower than the anterior, a sharp re-entering sinus between them. Sometimes the last bars are somewhat irregular, interrupted or wavy in their anterior part, but this feature is variable and often absent (compare Marshall's figure, 1890, fig. 1). Shell rather flat and compressed, disk only slightly convex. An indistinct, blunt posterior ridge is present. Greatest diameter of the shell at, or immediately in front of, this ridge. Behind the ridge the posterior slope appears more or less compressed and winged. Surface without sculpture.

Epidermis yellowish to greenish, or, when old, blackish, with more or less distinct green to blackish rays, which are straight, narrow or broad, often consisting of bundles of capillary rays. Generally the posterior slope is darker green on account of the more crowded rays. In old shells the rays become obscure, and the whole surface turns greenish black. Growth-rests rather distinct, and mostly marked by darker (brown) color.

Hinge-teeth well-developed, but not heavy, rather delicate. Pseudocardinals lamellate, directed forwards, and almost parallel to the hinge. Interdental projection of left valve well-developed, fitting into an interdental groove of the right valve. Lateral teeth rather long, straight, well-developed, but thin. Beak-cavity shallow. Dorsal muscle-scars in beak-cavity. Nacre white, often cream-color or even pale salmon or flesh-color towards the beak-cavity.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Linesville, Cat. No. 61.874 | 121 mm. | 67 mm. | 39 mm. |
| 2. Shenango, Cat. No. 61.4218 | 91 " | 55 " | 29 " |
| 3. do. do. | 87 " | 53 " | 28 " |
| 4. do. do. | 50 " | 31 " | 12 " |

*Soft parts* (See Ortmann, 1912, p. 281). *Glochidia* (See Lea, Obs. VI, 1858, Pl. 5, fig. 23; Ortmann, 1911, Pl. 89, fig. 10; Surber, 1912, Pl. 3, fig. 44). Surber gives the dimensions as $0.353 \times 0.313$ mm., while I found them to be: $0.34 \times 0.28$ mm.

This species normally is *hermaphroditic,* and I never have found a specimen in Pennsylvania having the male structure of the gills. However on rare occasions individuals with male structure seem to turn up. I have recorded (1911*b*, p. 309) such a case from Lake Erie, but this has remained the only one.

*Breeding season:* Gravid specimens were found on August 6, 1908; August 7, 1908; August 13, 1906; August 18, 1909; August 23, 1916; August 29, 1910; Sept. 2, 1908; Sept. 3, 1908; Sept. 4, 1908; Sept. 7, 1908; Sept. 7, 1913; Sept. 10, 1906; Sept. 14, 1908; Sept. 18, 1916; Sept. 21, 1908; Sept. 27, 1909; Oct. 4, 1910; Oct. 10, 1907; Oct. 15, 1907; Oct. 19, 1908; and then again on May 14, 1908; May 22, 1908; May 23, 1908; June 2, 1908; June 17, 1909. The first record for glochidia is on Sept. 7, while discharging specimens have been observed on May 23, and June 2 and 17.

Thus this species is clearly *bradytictic,* beginning to breed early in August, gravidity lasting till May and June of the following year, when the glochidia are discharged. The interim between two succeeding breeding seasons falls into the second half of June and in July.

*Remarks:* As to the specific name see the controversy between Frierson (1915, p. 57) and Walker (1915, p. 74).

This is a species easily recognized by the shape and color of the shell, and by the conformation of the hinge. It can only be confused with its nearest relative, *L. subviridis,* but only in the young stage. Young specimens of *L. viridis* indeed somewhat resemble older specimens of *L. subviridis* (Compare figs. 2 and 4, on Plate IX) but they are always more distinctly trapezoidal, with well-developed posterior wing. In other respects the size of full-grown specimens distinguishes the two species at once. In Pennsylvania the geographical distribution is a good diagnostic character, but this is not the case in New York, where the two species overlap.

There is not much variation in the shell. The posterior wing may be more or less developed, and the shell may be more or less elevated at the upper posterior

angle. The degree of compression is also variable; some specimens being more swollen in the region of the posterior ridge than others. Furthermore, some specimens are more elongated than others, but all these are individual variations, and I never have noticed any distinct tendency to form local races.

Specimens from Conneaut Creek (Erie-drainage) do not differ from the normal form of the Ohio-drainage. Specimens from the headwaters of the Genesee River are identical with the type. The only two specimens I collected from Lake Erie were not from the lake proper, but from beach-pools, cut off from the lake by

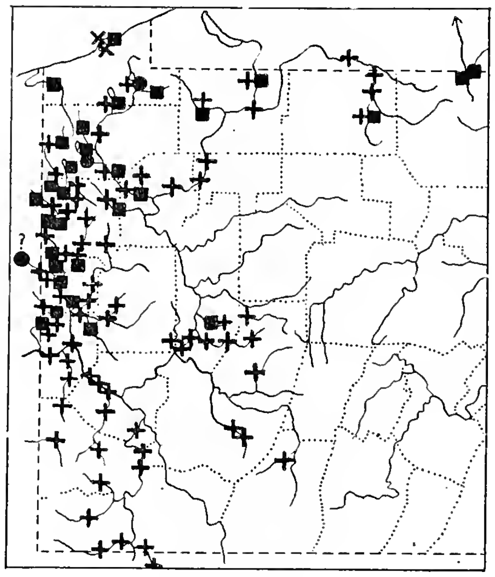

Fig. 12.

■ *Lasmigona viridis.*
● *Lasmigona complanata.*
+ *Lasmigona costata.*
× *Lasmigona costata eriganensis.*

sand-bars. They are entirely normal, but have a peculiar rusty brown tint in the epidermis, such as is found in other Naiades from Lake Erie, and especially in specimens from the beach-pools. A third individual from the lake, from Cedar Point, Ohio, is also normal in color.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Little Beaver Creek, Cannelton (Miss Vera White) (H. H. Smith), Darlington and New Galilee, Beaver Co.; Enon Valley, Lawrence Co.

*Beaver-drainage:*

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Brush Creek, Celia, Beaver Co.
Mahoning River, Mahoningtown, Lawrence Co.
Neshannock Creek, Eastbrook, Lawrence Co.

Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Sharpsville, Clarksville, Shenango, and Jamestown, Mercer Co.; Linesville, Crawford Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Little Shenango River, Greenville, Mercer Co.
Randolph Run, Hartstown, Crawford Co.

*Allegheny-drainage:*

Cowanshannock Creek, Rural Valley, Armstrong Co. (N. M. Grier).
Sandy Creek, Sandylake, Mercer Co.
French Creek, Utica, Venango Co.; Cochranton, Crawford Co.; Union City, Erie Co.
Conneaut Outlet, Conneautlake, Crawford Co.
Cussewago Creek, Mosiertown, Crawford Co. (H. & L. Ellsworth).
Conneauttee Creek, Edinboro, Erie Co.
Brokenstraw Creek, Garland, Warren Co.
Connewango Creek, Russell, Warren Co.
Potato Creek, Smethport, McKean Co. (P. E. Nordgren).

*Lake-drainage:*

Conneaut Creek, West Springfield, Erie Co.
Lake Erie, beach-pools of Presque Isle, Erie, Erie Co.
Genesee River, Genesee, Potter Co.
Cryder Creek, Genesee, Potter Co.

*Other localities represented in the Carnegie Museum:*

Lake Erie, Cedar Point, Erie Co., Ohio (C. Brookover).
Tenmile Creek, Lucas Co., Ohio (C. Goodrich) (lake-drainage).
Beaver Creek, Williams Co., Ohio (C. Goodrich).
Raisin River, Adrian, Lenawee Co., Michigan (C. Goodrich).
West Branch Nimishillen Creek, Canton, Stark Co., Ohio.
Tuscarawas River, Tuscarawas Co., Ohio (Holland collection).
North Fork Hughes River, Cornwallis, Ritchie Co., West Virginia.

*Distribution and Ecology in Pennsylvania* (See fig. 12): The distribution of this species in Pennsylvania is very peculiar, but, as we shall see later, there are several similar cases. It belongs exclusively to the northwestern part of the state, including Little Beaver Creek, the drainage of Beaver River and most of its tributaries, some tributaries of the middle and upper Allegheny (Cowanshannock, Sandy, French, Brokenstraw, Connewango, Potato Creeks), Lake Erie and its drainage, and the upper Genesee River. It has never been found in the Allegheny proper and its drainage from Armstrong Co. down, and is entirely missing in the Ohio proper and in the whole Monongahela system.

Thus it seems as if this species in its distribution does not follow the courses of the rivers, but rather goes across country in the northwestern part of the state, and the relation of its area to that of the Glacial deposits is very close. Only in Little Beaver Creek, below New Galilee, in Brush Creek (tributary to the Con-

noquenessing), Cowanshannock Creek (to middle Allegheny), and Potato Creek (flowing into the uppermost Allegheny), is it outside of the Terminal Moraine, but never far from it. The explanation of this peculiar fact will be attempted elsewhere; here it suffices to direct attention to it, in order that the case may be kept in mind.

As regards its ecology, *L. viridis* is in Pennsylvania distinctly a form of the smaller streams, going up far into the headwaters, into streams which are indeed the smallest in Pennsylvania, which contain mussels. Also Wilson & Clark (1912*a*) have observed that it belongs to the small creeks in the upper Kankakee-drainage in Indiana. Wherever I found this species, it seems to be averse to very strongly flowing waters (in riffles); its usual station is near (below) riffles, where there is a moderate flow of water over coarser or finer gravel, packed firmly by fine sand or mud. It is generally not an abundant species, but locally it has been taken in some numbers. In the beach-pools of Lake Erie I found it in the characteristic sand of the lake-shores, with a scanty vegetation of algæ.

*General distribution: Type locality,* rare in the Ohio, more common in the Kentucky and small tributaries (Rafinesque).

Simpson (1900) condenses the range as follows: "Ohio and St. Lawrence drainages areas; west to Arkansas, north through Nebraska to Wisconsin; Hudson River." This, however, does not bring out the chief feature of the distribution. This species is distinctly more northern, and its main range is north of the Ohio in Illinois, Indiana, Michigan, Ohio, and Pennsylvania; it crosses over into the lake-drainage (Walker, 1913), and has in the St. Lawrence system a great extension eastwards, crossing over in New York into the Atlantic-drainage (Mohawk and Hudson Rivers). In Canada, it goes as far as the vicinity of Ottawa and Montreal (Marshall, 1895), and extends to Vermont (Call, 1878, and Gray, 1883). It also has been reported from Connecticut.[77]

In this eastern extension of its range it invades in part that of the next species (*L. subviridis*), but it is not known whether it is found in any one locality associated with the latter. Probably it went here (as did *Fusconaia flava*) by way of the Erie Canal, although Call suggests the possibility of distribution by birds.

In the southward direction, in southwestern Pennsylvania, as indicated above, and generally to the South of the Ohio River, it is missing or rare. I have never found it in the Ohio proper from Pittsburg down to Cincinnati, although it is mentioned in the Cincinnati list (Harper, 1896). I have found a single individual

[77] New Haven Canal, according to Linsley (1845), but not mentioned by Perkins (1869). Adams (1842) has distinguished this eastern form as var. *plebeia* (See Simpson, 1914, p. 483, and Johnson, 1915, p. 25).

in North Fork Hughes River, a tributary of the Little Kanawha, and, for the present I regard this as a stray specimen. Rafinesque gives it from Kentucky, also Baker (1898*a*, p. 60), but it is unknown from the Cumberland and Tennessee. The distribution seems to be also very restricted in a southwesterly and westerly direction. The records from Arkansas and Iowa are very vague, and certainly need verification (for Iowa, see Geiser, 1910). It is absent from Call's Arkansas list (1895), and from Scammon's Kansas list (1906). It is abundant in northern Illinois, and passes into parts of Wisconsin and Minnesota, and also into eastern Nebraska. But the exact boundaries in this region require further investigation.

### LASMIGONA (PLATYNAIAS) SUBVIRIDIS (Conrad) (1835).

*Symphynota viridis* SIMPSON, 1914, p. 484; *Lasmigona subviridis* (CONARD) FRIERSON, 1915, p. 58.

Plate IX, figs. 3, 4.

*Records from Pennsylvania:*

Conrad, 1836 (Schuylkill River, Philadelphia; Lancaster; Juniata River).
Lea, 1838 (Juniata River, Hollidaysburg, Blair Co.).
Haldeman, 1844 (Lancaster Co.).
Conrad, 1856 (Schuylkill River, Phoenixville, Chester Co.; Delaware River, Morrisville, Bucks Co.: "opposite Trenton").
Bruckhart, 1869 (Lancaster Co.).
Hartman & Michener, 1874 (Schuylkill River, Chester Co.).
Marshall, 1895 (Juniata River and Philadelphia).
Ortmann, 1909*b*, p. 206.

*Characters of the shell:* Shell very much like that of *L. viridis*, but invariably much smaller, thinner, and more delicate, with the hinge-teeth thin and weak. The interdental projection of the left valve is quite rudimentary, and generally, no indication of it is present. The outline of the shell is not so distinctly trapezoidal, but rather subovate, narrower in front, higher behind, and the upper margin forms only a blunt angle with the posterior margin. The two valves are not so distinctly compressed, as in *L. viridis*, and the swelling in the region of the posterior ridge is generally more pronounced, so that the whole shell appears relatively more inflated. Beak-sculpture similar to that of *L. viridis*, but the bars are stronger and less in number (four); they do not extend so far upon the disk, are more equal, with the posterior loop not so sharply angled (See Marshall, 1890, p. 176, fig. 2). Epidermis yellowish brown to olive greenish, with more or less distinct green rays, which are most distinct and crowded upon the posterior slope, so that the latter generally appears darker green. Nacre white and iridescent, but often with lurid or dirty salmon tints.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Greencastle, Cat. No. 61.4222 (largest at hand) | 63 mm. | 38 mm. | 26 mm. |
| 2. Yardley, Cat. No. 61.3689 | 55 " | 32 " | 20 " |
| 3. do. do. | 51 " | 31 " | 19 " |
| 4. do. do. | 41 " | 25 " | 15 " |

*Soft parts* (See Ortmann, 1912, p. 282). *Glochidia* (See Lea, Obs. XII, 1874, Pl. 21, fig. 4). Measurements: 0.36 × 0.30 mm.

This species is also normally *hermaphroditic,* and specimens with male structure have never been found. Since the first publication of this fact I have examined several hundreds of additional specimens, but all had the female characters in the gills.

*Breeding season:* Gravid females have been collected at the following dates: Aug. 13, 1910; Aug. 20, 1909; Aug. 24, 1908; Sept. 5, 1909; Sept. 6, 1909; Sept. 12, 1912; Sept. 14, 1912; Sept. 16, 1912; then again: April 24, 1909; May 6, 1912; June 8, 1912. Thus the season begins about the middle of August. The first date for the presence of glochidia is September 5. The glochidia are carried

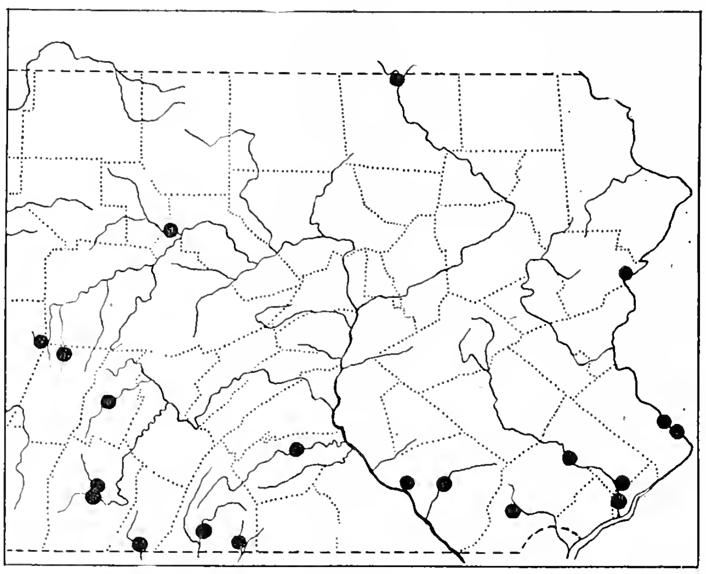

FIG. 13.

● *Lasmigona subviridis.*

over the winter, and discharge was observed on the last date, June 8. The species is *bradytictic.*

*Remarks:* Although this species morphologically is closely allied to *L. viridis,* and is undoubtedly its eastern representative, and although the differences are only in the degree of development of certain characters, it is not difficult to distinguish it at the first glance on account of the shape and size of shell. The range

of variation is not very great, and chiefly lies in the color of the epidermis. One peculiar local phase, however, deserves special mention. In Conococheague Creek at Greencastle, Franklin Co., this species is represented by rather large specimens, which have an unusually heavy shell, with the nacre more frequently of a clear salmon color, and the beaks in a beautiful state of preservation, even in large individuals. This creek, at that locality, is so heavily charged with lime (fed by big limestone springs), that a deposit of calcareous ooze is formed at the bottom, and there is no doubt, that the peculiar local development is due to these local conditions. Something similar, but not so strongly pronounced, has been observed in Conedoguinet Creek at Carlisle; and in Virginia, in Reed Creek at Wytheville, under the same conditions, a form has been observed, which corresponds entirely to this form from Greencastle.

*Localities in Pennsylvania represented in the Carnegie Museum:*

*Delaware-drainage:*

Delaware River, Yardley, Bucks Co.; Shawnee, Monroe Co.
Schuylkill Canal, Manayunk, Philadelphia Co.

*Susquehanna-drainage:*

Conedoguinet Creek, Carlisle, Cumberland Co.
Dunning Creek (J. F. L. Raschen) and Raystown Branch of Juniata River (A. Koenig), Bedford, Bedford Co.
Chest Creek, Patton, Cambria Co.
Cush Cushion Creek, Green Township, Indiana Co. (D. A. Atkinson).
Chemung River, South Waverly, Bradford Co.

*Potomac-drainage:*[78]

Conococheague Creek, Greencastle, Franklin Co.
Great Tonoloway Creek, Thompson Township, Fulton Co.

*Localities in Pennsylvania represented in the Philadelphia Academy of Natural Sciences:*

"Valley Creek"[79] southwest of Coatesville, Chester Co. (C. H. Conner).
Pennsylvania Canal, "Chieques,"[80] Pennsylvania (S. S. Haldeman).
Sinnemahoning Creek, Round Island, Clinton Co. (S. N. Rhoads).

*Other localities represented in the Carnegie Museum:*

Delaware-Raritan Canal, Princeton, Mercer Co., New Jersey.
South Branch Potomac River, Southbranch and Romney, Hampshire Co., West Virginia.

[78] I found this species abundant in Little Antietam Creek, Waynesboro, Franklin Co., but the specimens collected (about a dozen), on Aug. 10, 1910, were lost during the trip in an unaccountable way.

[79] There is no creek of this name on the map, but "Sucker Run" is in the "valley" southwest of Coatesville, tributary to West Branch Brandywine Creek.

[80] No doubt "Chickies," near Columbia, Lancaster Co.

Shenandoah River, Harpers Ferry, Jefferson Co., West Virginia.
South Fork Shenandoah River, Elkton, Rockingham Co., Virginia.
Rappahannock River, Remington, Fauquier Co., Virginia.
Rapidan River, Rapidan, Culpeper Co., Virginia.
North River, Buena Vista, Rockbridge Co., Virginia.

*Kanawha-drainage:*

Pool of Kanawha River, Glen Ferris, Fayette Co., West Virginia.
Greenbrier River, Ronceverte, Greenbrier Co., West Virginia.
New River, Hinton, Summers Co., West Virginia; Pearisburg, Giles Co., Virginia.
Reed Creek, Wytheville, Wythe Co., Virginia.

*Distribution and Ecology in Pennsylvania* (See fig. 13): According to the records at hand, this species is very erratic in its distribution. It is found in all three drainages on the Atlantic side, but it is evident that it avoids the large rivers and prefers smaller streams. Its absence in the lists of Gabb (1861)[81] and Schick (1895) is significant, although, as I have discovered, it is abundant in the Schuylkill Canal at Manayunk. The specimens found by myself in larger rivers generally were few, and often in small branches of the river.

But even in small streams, it is not everywhere present. But generally, when found, it turned up abundantly. Like the preceding species (*L. viridis*), it is averse to very strong current, and prefers more quiet parts, pools or eddies with gravelly and sandy bottoms, and it also goes into canals, where it seems to flourish. In the Susquehanna-drainage it goes far up into the headwaters, advancing westward to Bedford, Cambria, and Indiana Cos.

Outside of Pennsylvania, it is found under similar conditions, and is also more abundant in smaller streams. In the Kanawha-drainage it descends to the big pool above the Kanawha falls, where it lives in an environment resembling a lake.

*General distribution: Type locality,* Frankstown Branch Juniata River, Hollidaysburg, Blair Co., Pennsylvania (Conrad).

Simpson (1900) gives: "streams draining into the Atlantic from New York south to North Carolina," and "Monroe Co., Michigan?". Of course, this latter locality, doubted already by Walker (1898), is certainly incorrect. We possess the largest number of locality records, outside of Pennsylvania, from the state of New York (Marshall, 1895), where it is found in the drainages of the Susquehanna and Hudson Rivers, and it goes westwards through the Mohawk into the Erie Canal, reaching the Genesee River (See Baker, 1898*b*). As has been said above, in this region it overlaps *L. viridis*, but particulars as to the mutual relations of these two species are absent.

[81] Gabb mentions it as a species, which might be found near Philadelphia. Conrad (1836) reports a single individual from the Schuylkill at Philadelphia.

South of Pennsylvania records become scarce, and aside from those given by myself we have only the following: Sideling Creek, Allegany Co., Maryland (Pilsbry, 1894); Richmond, Henrico Co., Virginia (Lea's *U. hyalinus*); and Neuse River, Raleigh, Wake Co., North Carolina (Lea's *U. pertenuis*).

My discovery of the presence of this species in the upper Kanawha-drainage in Virginia and West Virginia is quite astonishing and has been discussed elsewhere (Ortmann, 1913*a*, p. 371, fig.). It should be added, that further investigations have traced this species down to the Big Pool of the Kanawha (at Glen Ferris, in Fayette Co., West Virginia).

### Subgenus Lasmigona Rafinesque (1831).

Simpson, 1914, p. 488; Ortmann, 1914, p. 43.

Type *Alasmidonta costata* Rafinesque.

One species and one variety belong here.

Key to the Forms of Lasmigona.

$a_1$. Shell compressed, not subcylindrical .......... *L.* (*L.*) *costata.*
$a_2$. Shell more swollen, and thus more nearly subcylindrical .......... *L.* (*L.*) *costata eriganensis.*

### Lasmigona (Lasmigona) costata (Rafinesque) (1820).

*Symphynota costata* (Rafinesque) Simpson, 1914, p. 488.

Plate IX, fig. 5.

*Records from Pennsylvania:*

Harn, 1891 (western Pennsylvania).
Stupakoff, 1894 (Allegheny Co.).
Marshall, 1895 (Allegheny River, Warren Co.).
Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co.; Beaver River, Wampum, Lawrence Co.).
Ortmann, 1909*b*, p. 196.

*Characters of the shell:* Shell rather large, moderately solid. Outline subrhomboidal or subtrapezoidal, more or less elongated. Anterior end rounded, posterior obliquely truncate. Lower margin gently convex, or almost straight. Upper margin straight or slightly curved, somewhat ascending posteriorly, and forming a rounded angle with the posterior margin. Beaks not prominent, placed in front of the middle of the shell. Beak-sculpture consisting of about four or five bars, which are rather heavy and swollen, the first simply curved, the others with a tendency to fall into two loops, but this is distinct only in the second and third bar, where the posterior loop is angled, and the sinus is present, but not

sharp. The later bars are only developed in the middle, and have only a slight sinuation (see Marshall's figure, 1890, fig. 10). Shell rather flat, and more or less compressed, with an indistinct, blunt posterior ridge. Greatest diameter in the middle of the disk, or somewhat posterior to it, immediately in front of the posterior ridge, and in this case the sides of the disk are flattened. Behind the posterior ridge, the posterior slope is corrugated by heavy, blunt ridges or ribs, running toward the posterior margin. In front of the posterior ridge, the disk is smooth, without sculpture (sometimes there are short vertical grooves, such as are found incidentally also in other Naiades).

Epidermis yellowish or brownish olive, greenish, brownish or blackish, with more or less distinct, narrower or broader, dark green rays, which disappear in old shells, which are more or less uniformly brownish or greenish black. Growth-rests irregular, more or less distinct, often marked by darker bands.

Hinge partly obliterated. The pseudocardinals are moderately developed (sometimes heavy in old shells), of the characteristic Anodontine type (more or less lamellar and directed obliquely forwards), with the interdental projection very well developed. Lateral teeth practically absent, or indicated only by mere rudiments. Beak-cavity shallow. Dorsal muscle-scars in the beak-cavity. Nacre white, often cream-color or pale salmon, chiefly so toward the beak-cavities.

No material sexual differences are seen in the shell. It has been asserted by Scammon (1906) that the shell of the female is shorter and more inflated, while Call (1900, p. 525) says that the females are a little more obese than the males. According to my experience large specimens, which are rather swollen just in front of the posterior ridge, are generally females (See Nos. 1 and 3 in table of measurements) but there are females, which do not show this character (See No. 2), and in medium-sized and small shells it is not at all developed (Compare Nos. 4–9). As a rule, it is not easy to positively identify the sex by the shell alone, and in younger shells this is impossible. That the females are shorter than the males is not at all correct (See table of measurements).

| | L. | H. | D. | |
|---|---|---|---|---|
| *Size:* 1. Enon Valley, Cat. No. 61.3134 | 149 mm. | 86 mm. | 50 mm. | (swollen ♀, largest at hand) |
| 2. do. do. | 137 " | 76 " | 37 " | (flat ♀) |
| 3. Waynesburg, Cat. No. 61.4709 | 134 " | 77 " | 45 " | (swollen ♀) |
| 4. Harbison, Cat. No. 61.4710 | 126 " | 71 " | 35 " | (swollen ♂) |
| 5. Mount Morris, Cat. No. 61.4711 | 126 " | 67 " | 36 " | (♀) |
| 6. Waynesburg, Cat. No. 61.4709 | 122 " | 72 " | 35 " | (♂) |
| 7. Harbor Bridge, Cat. No. 61.3709 | 122 " | 67 " | 32 " | (flat ♀, gravid!) |
| 8. Harbison, Cat. No. 61.4710 | 75 " | 41 " | 19 " | (♂) |
| 9. Wurtemberg, Cat. No. 61.4712 | 73 " | 41 " | 18 " | (♀) |

*Soft parts* (See Ortmann, 1912, p. 283). *Glochidia* (See Lea, Obs. VI, 1858, Pl. 5, fig. 26; Lefevre & Curtis, 1910, p. 97, fig. B, and 1912, p. 146, fig. B; Surber, 1912, Pl. 1, fig. 7). Surber gives the following dimensions: 0.385 × 0.390; Lefevre & Curtis: 0.35 × 0.39; while I (1912) give: 0.34 × 0.37 mm.

*Breeding season:* I have the following records for gravid females: August 3, 1909; Aug. 8, 1914; Aug. 9, 1907; Aug. 23, 1916; Aug. 29, 1910; Aug. 31, 1906; Sept. 2, 1907; Sept. 2, 1908; Sept. 4, 1908; Sept. 5, 1908; Sept. 5, 1913; Sept. 7, 1908; Sept. 7, 1913; Sept. 10, 1906; Sept. 11, 1913; Sept. 12, 1913; Sept. 13, 1910; Sept. 13, 1915; Sept. 15, 1913; Sept. 17, 1912; Sept. 17, 1917; Sept. 18, 1917; Sept. 21, 1907; Sept. 21, 1908; Sept. 27, 1909; Sept. 28, 1911; Oct. 4, 1910; Oct. 14, 1907; Oct. 15, 1907; Oct. 19, 1908; Oct. 23, 1907. Then again in spring: April 22, 1908; April 24, 1908; May 11, 1907; May 11, 1911; May 13, 1910; May 17, 1910; May 26, 1908.

Thus this species is *bradytictic*. The breeding season begins early in August, and by the end of this month (earliest date Aug. 31), and in September, glochidia begin to be present. They are carried over the winter, and are found in the marsupium in April and May, and are discharged during May (observed on May 11 and 13). In June and July, there is an "interim," and although many specimens were collected, there never was in these months a gravid female among them.

*Remarks:* This species is easily recognized by the general shape, sculpture of the posterior slope, and conformation of the hinge. From *L. viridis*, which it resembles somewhat in shape, it differs also in beak-sculpture. Variations are chiefly due to differences in the relation of length to height, and the development of the sculpture of the posterior slope, which may be coarser or finer, and may be more or less distinct; but traces of this sculpture are always present. I have not been able to discover any marked tendency in the direction of the development of local races, unless it be in size, the forms of certain creeks always remaining comparatively small. This is especially true of some little streams in the mountains (upper Loyalhanna River in Westmoreland Co., Quemahoning Creek in Somerset Co., Little Mahoning Creek in Indiana Co.). Other small creeks, chiefly in the northwestern part of the state, favor the development of almost gigantic forms, for instance, Little Beaver Creek, the upper Shenango River, and others.[82]

[82] I found outside of our state in the upper Tygart River at Elkins, Randolph Co., West Virginia, a rather interesting local form, with a very pronounced tendency toward the obliteration of the sculpture of the posterior slope, which in these specimens in most cases is perfectly smooth, although individuals occur, which show rudiments of the ribs.

*Localities in Pennsylvania represented in the Carnegie Museum:*

*Ohio River and its smaller tributaries:*

Ohio River, Industry, Beaver Co.; Dead Man's Island, Allegheny Co. (R. Foerster); Neville Island, Allegheny Co.

Buffalo Creek, Acheson, Washington Co.

Little Beaver Creek, Cannelton (Miss Vera White, H. H. Smith), Darlington and New Galilee, Beaver Co.; Enon Valley, Lawrence Co.

Raccoon Creek, New Sheffield, Beaver Co.; Bavington, Washington Co.

Chartiers Creek, Carnegie, Allegheny Co. (D. A. Atkinson).[83]

*Beaver-drainage:*

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).

Connoquenessing Creek, Ellwood City, Lawrence Co. (G. H. Clapp & H. H. Smith); Harmony, Butler Co.

Slipperyrock Creek, Wurtemberg and Rose Point, Lawrence Co.

Wolf Creek, Grove City, Mercer Co.

Little Connoquenessing Creek, Harmony, Butler Co.

Mahoning River, Mahoningtown, Coverts, Edinburg and Hillsville, Lawrence Co.

Neshannock Creek, Volant, Lawrence Co.; Leesburg, Mercer Co.

Otter Creek, Mercer, Mercer Co.

Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Sharpsville, Clarksville, Shenango, and Jamestown, Mercer Co.; Linesville, Crawford Co.

Pymatuning Creek, Pymatuning Township, Mercer Co.

Little Shenango River, Greenville, Mercer Co.

*Allegheny-drainage:*

Allegheny River, Godfrey, Kelly, Mosgrove, and Templeton, Armstrong Co.; Walnut Bend, Venango Co.; Tionesta and Hickory, Forest Co.; Warren, Warren Co.; Eldred, McKean Co.; Larabee, McKean Co. (Dennis Dally).

Buffalo Creek, Harbison, Butler Co.

Loyalhanna River, Idlepark and Ligonier, Westmoreland Co.

Two Lick Creek, Homer, Indiana Co.

Quemahoning Creek, Stantons Mill, Somerset Co.

Crooked Creek, Rosston and South Bend, Armstrong Co.; Creekside, Indiana Co.

Cowanshannock Creek, Rural Valley, Armstrong Co. (N. M. Grier).

Little Mahoning Creek, Goodville, Indiana Co.

Sandy Creek, Sandy Lake, Mercer Co.

French Creek, Utica, Venango Co.; Cochranton and Meadville, Crawford Co.

Sugar Creek, Cooperstown, Venango Co. (E. P. Spencer).

Conneauttee Creek, Edinboro, Erie Co.

Leboeuf Creek, Waterford, Erie Co.

Brokenstraw Creek, Garland, Warren Co.

Connewango Creek, Russell, Warren Co.

Potato Creek, Smethport, McKean Co. (P. E. Nordgren).

*Monongahela-drainage:*

Monongahela River, Elizabeth, Allegheny Co. (D. A. Atkinson); Charleroi, Washington Co. (G. A. Ehrmann); Westmoreland Co. (G. A. Ehrmann).

[83] Dead shell seen in Little Chartiers Creek, Morganza, Washington Co.

Ten Mile Creek, Amity, Washington Co.
South Fork Ten Mile Creek, Waynesburg, Greene Co.
Dunkard Creek, Wiley and Mount Morris, Greene Co.
Cheat River, Cheat Haven, Fayette Co.

*Localities in Pennsylvania represented in the Philadelphia Academy of Natural Sciences:*

Ohio River, Beaver, Beaver Co., and Coraopolis, Allegheny Co. (S. N. Rhoads).

*Other localities represented in the Carnegie Museum:*

*Atlantic- and Lake-drainage:*

Mohawk River, New York (Smith collection).
Sandusky River, Upper Sandusky, Wyandot Co., Ohio (C. Goodrich).
Miami and Erie Canal, Waterville, Lucas Co., Ohio (C. Goodrich).
Maumee River, Waterville, Lucas Co., and Defiance, Defiance Co., Ohio (C. Goodrich).
St. Marys River, Rockford, Monroe Co., Ohio (C. Goodrich).
Raisin River, Grape P. O., Monroe Co., Michigan (C. Goodrich).
Kaministiquia River, Stanley, western Ontario, Canada (O. E. Jennings).[84]

*Ohio-drainage:*

Ohio River, Portsmouth, Scioto Co., Ohio.
Wolfe Creek, Washington Co., Ohio (W. F. Graham).
Scioto River, Kenton, Hardin Co., Ohio (C. Goodrich).
Rock River, Illinois (Smith collection).
Cheat River, Jaco and Mount Chateau, Monongalia Co., West Virginia.
West Fork River, Lynch Mines, Harrison Co.; Lightburn and Weston, Lewis Co., West Virginia.
Tygart River, Elkins, Randolph Co., West Virginia.
Little Kanawha River, Grantsville, Calhoun Co. (W. F. Graham); Burnsville, Braxton Co., West Virginia.
North Fork Hughes River, Cornwallis, Ritchie Co., West Virginia.
Elk River, Sutton and Gassaway, Braxton Co.; Shelton, Clay Co., West Virginia.
Levisa Fork Big Sandy River, Prestonsburg, Floyd Co., Kentucky.
Licking River, Farmer, Rowan Co., Kentucky.

*Tennessee-drainage:*

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).
Bear Creek, Burleson, Franklin Co., Alabama (H. H. Smith).
Shoals Creek, Lauderdale Co., Alabama (H. H. Smith).
Elk River, Fayetteville, Lincoln Co., and Estill Springs, Franklin Co., Tennessee (H. H. Smith).
Flint River and Hurricane Creek, Gurley, Madison Co., Alabama (H. E. Wheeler).
Paint Rock River, Trenton and Princeton, Jackson Co., Alabama (H. H. Smith).
South Chickamauga Creek, Ringgold, Catoosa Co., Georgia.
Tennessee River, Knox Co., Tennessee (Smith collection).
Boyd Creek, Boyd Creek, Sevier Co., Tennessee.
Holston River, Mascot, Knox Co.; Hodges, Jefferson Co.; Turley Mill, Noeton, and Holston Station, Grainger Co.; Austin Mill and Church Hill, Hawkins Co., Tennessee.

[84] About 15 miles west of Fort Williams on the Kaministiquia River, which flows to Lake Superior, but it might have a connection with the Hudson Bay-drainage. Special attention should be called to this new locality!

South Fork Holston River, Pactolus, Bluff City, and Emmett, Sullivan Co., Tennessee.
Middle Fork Holston River, Chilhowie, Smyth Co., Virginia.
North Fork Holston River, Rotherwood, Hawkins Co., Tennessee; Hilton, Scott Co., Virginia; Mendota, Washington Co., Virginia; Saltville, Smyth Co., Virginia.
Clinch River, Edgemoor and Offutt, Anderson Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Speers Ferry and Clinchport, Scott Co., Virginia; St. Paul, Wise Co., Virginia; Fink and Cleveland, Russell Co., Virginia; Raven, Richland, and Cedar Bluff, Tazewell Co., Virginia.
Powell River, Combs, Claiborne Co., Tennessee; Dryden, Lee Co., Virginia.

*Distribution and Ecology in Pennsylvania* (See fig. 12): This species is widely distributed in the headwaters of the Ohio in western Pennsylvania, and is found in large rivers as well as in very small creeks, although it is distinctly more abundant in the latter. There is hardly any small stream from which it is entirely absent, but in the large rivers, although present, it is decidedly rare.

The wide and general distribution of this species indicates that it is not very particular as to station. It is found under a great variety of conditions, in riffles, with a strong and variable current, in steady, stronger or weaker currents, and even in rather quiet water and deep pools. It is found on every variety of bottom, but prefers coarser or finer gravel, and more rarely is seen in sand and mud. It is one of the few species, which advances far eastwards in the headwaters of the Conemaugh and Allegheny drainages, but although it closely approaches the divide, it has never been found in Pennsylvania to the east of it in the Atlantic-drainage.

It has not been found in the only tributary of Lake Erie in our state, which has shells (Conneaut Creek).

*General distribution: Type locality,* Kentucky River (Rafinesque).

This species has an enormous range. It is found practically all over the Mississippi and Ohio-drainages, from western Pennsylvania throughout Ohio, Indiana, Illinois, West Virginia, Kentucky, and Tennessee to northern Alabama. In the upper Tennessee-drainage it goes by the Powell, Clinch, and Holston Rivers into Virginia. In a southwesterly direction it extends to eastern Kansas, through Arkansas to Oklahoma and northern Louisiana.

Simpson cites it from Columbus, Lowndes Co., Mississippi, in the Tombigbee-drainage, but this is the only place from which it has been recorded in the Alabama system.

Westward it does not seem to go beyond Iowa (abundant in the Wapsipinicon, Volga, and Turkey Rivers, in northeastern Iowa, according to Geiser, 1910), but in a northerly direction it has crossed over into the Hudson Bay-drainage in Manitoba, and possibly our locality in a northern tributary of Lake Superior (Kaministiquia River), is connected with this region.

In the drainage of the Great Lakes, from Wisconsin through Michigan to New York and eastern Canada it is widely distributed. However this latter part of its range should be investigated more closely. As we shall presently see, in Lake Erie a peculiar local variety has been developed. Nevertheless in the lake-drainage in western and central New York the normal type is present. Here it advances along the Erie Canal to the Mohawk and even to the Hudson River. It follows the lower St. Lawrence down to the neighborhood of Ottawa and Montreal (and also occurs in the Lake Champlain region), but it is not known whether the form peculiar to Lake Erie or the normal type prevails here.

It should be further noted that the rule that this species is rare in large rivers holds good also in the Ohio below Pittsburgh. Between the Pennsylvania state-line and Cincinnati, I found only a single individual (in a clam-digger's pile at Portsmouth, Scioto Co., Ohio). This is in strong contrast to the abundance of this species in some of the smaller creeks in West Virginia and Kentucky.

### LASMIGONA (LASMIGONA) COSTATA ERIGANENSIS Grier (1918).

A form, not distinguished hitherto, except by Sterki (1907*a*, p. 393) who called attention to its peculiarities, and by Grier (1918, p. 10) who elevated it to the rank of a variety.

Plate IX, fig. 6.

*Characters of the variety:* Shell smaller, slightly more elongate, more swollen, and thus approaching in a degree the subcylindrical shape. Ridges of posterior slope generally narrower. Color lighter, more yellowish-brown, sometimes rusty brown, with the rays indistinct, and the growth-rests more distinct and more regular.

| | | | L. | H. | D. | |
|---|---|---|---|---|---|---|
| *Size:* 1. | Presque Isle Bay, | Cat. No. 61.4223 | . . .90 mm. | 44 mm. | 31 mm. | Type Set |
| 2. | do. | do. | . . .88 " | 45 " | 26 " | " " |
| 3. | do. | do. | . . .85 " | 46 " | 29 " | " " |
| 4. | do. | do. | . . .76 " | 39 " | 28 " | " " |
| 5. | do. | do. | . . .73 " | 38 " | 25 " | " " |

Compared with the measurements of typical *costata* (p. 126), the differences in shape become evident, especially the greater diameter.

*Soft parts:* Living specimens have been found only on two occasions: May 22, 1909; and July 8, 1910. Although there were females among them, none were gravid. The soft parts of none were preserved, but as far as I am able to recollect, they were not different from the normal form.

*Remarks:* Although I have only fifteen specimens from Pennsylvania, and five from Michigan (to which might be added about half a dozen individuals used

in exchange) I feel quite sure, that Grier is right in thinking that this shell represents a very peculiar phase of *L. costata*. The whole outer aspect of this shell is quite unlike that of the normal form, but, of course, the sculpture of the posterior slope and the hinge do not leave any doubt as to its systematic relationship. As the above measurements show, there is some variation in shape, and furthermore the color of the epidermis may be lighter or darker, sometimes inclining more to brown, sometimes to rusty. Greenish tints are rarely seen.

*Localities represented in the Carnegie Museum:*

Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania.
Lake Erie, La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).

*Distribution and Ecology* (See fig. 12). *Type locality:* Lake Erie; Presque Isle Bay, Erie, Erie Co., Pennsylvania. *Type set:* Carnegie Museum Cat. No. 61.4223 (not 61.4720, as Grier states!).

I know this form only from the Lake Erie shores in Pennsylvania and Michigan, but according to Sterki it also occurs on the Ohio shores, and very likely will be found elsewhere in Lake Erie. Walker's (1913, p. 22) *S. costata* from Lake Erie is undoubtedly this form. The specimens collected by myself are all from the north shore of the bay "Big Bend," where I found them alive in one to three feet of water, on sand and fine gravel, without vegetation, and at places, which are exposed at times to a considerable surf. This form is not abundant there. Some specimens were found among a scanty growth of rushes (*Juncus americanus*).

*Note:* Since it is possible that *L. costata* of western New York may have come by way of Lake Erie, it is interesting to observe that the typical *L. costata* is found in this region, as indicated by De Kay's figure (1843, Pl. 14, fig. 226) from Oswego River (Lake Ontario-drainage). This possibly is a case parallel to others mentioned above, where the lake-form, when migrating into the tributaries, assumes again the shape of the normal creek-form. The matter, however, is not perfectly clear, for there is the possibility that western and central New York was reached by way of the upper Allegheny.

### Subgenus PTEROSYNA Rafinesque (1831).[85]

*Pterosygna* SIMPSON, 1914, p. 490; ORTMANN, 1914, p. 43.
Type *Unio complanatus* Barnes.

Only one species is known to belong to this subgenus.

[85] *Pterosyna*, and not *Pterosygna*, as Simpson writes.

## Lasmigona (Pterosyna) complanata (Barnes) (1823).

*Symphynota complanata* (Barnes) Simpson, 1914, p. 490.

Plate IX, fig. 7.

*Records from Pennsylvania:*

Ortmann, 1909*b*, p. 196.

*Characters of the shell:* Shell large; rather thin when young, moderately solid when old. Outline broadly ovate, subrhomboidal, not elongate, only a little longer than high. Anterior end rounded, posterior obliquely truncate. Lower margin convex, less so posteriorly. Upper margin nearly straight, strongly ascending posteriorly, forming a distinct angle with the posterior margin, and projecting so as to form a very distinct wing, the upper margin of which is symphynote. The wing is best developed in young specimens. Beaks not prominent, placed in front of the middle of the shell. Beak-sculpture consisting of four to five rather distinct and sharp bars, the first one or two simply curved, the others strongly double-looped, with the anterior loop round and wide, the posterior narrower and angled, and with a sharp, re-entering angle between them. Shell flat and greatly compressed, with an indistinct, blunt and broad posterior ridge. The posterior slope is alate and strongly compressed, and in many cases is ornamented with irregular ridges running toward the posterior margin, which, however, may be entirely absent. Disk in front of posterior ridge smooth, without sculpture.

Epidermis yellowish to greenish brown; when young with indistinct traces of green rays, which become entirely obsolete in older shells, of which the epidermis is lighter or darker brown, often blackish. Sometimes there is some dark green in the epidermis. Growth-rests more or less distinct, often marked by darker color.

Hinge-teeth partly obliterated. Pseudocardinals present and rather heavy, and quite variable in shape. Interdental projection variable, sometimes rather distinct; in other cases weak, and often entirely absent. Lateral teeth practically absent, indicated only by vestigial blunt ridges. The conformation of the hinge in this species is extremely and remarkably variable. Beak-cavity shallow. Dorsal muscle-scars in the beak-cavity. Nacre white, sometimes lightly tinted with cream-color toward the beak-cavity.

No differences in the shape of the shell in the two sexes. Baker (1898*a*, p. 60) and Scammon (1906, p. 332) say that the male is more compressed than the female. This is not at all correct, as is easily seen by comparing nos. 2, 3, and 4, and nos. 5 and 6 in our table of measurements.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Conneaut Outlet, Cat. No. 61.3315 (♂) | 124 mm. | 93 mm. | 40 mm. |
| 2. Waterford, Cat. No. 61.4238 (♂) | 118 " | 86 " | 40 " |
| 3. do. " " do. (♀) | 118 " | 84 " | 39 " |
| 4. Conneaut Outlet, Cat. No. 61.3315 (♀) | 117 " | 88 " | 35 " |
| 5. do. " " do. (♀) | 93 " | 71 " | 23 " |
| 6. Waterford, Cat. No. 61.4237 (♂) | 90 " | 65 " | 25 " |
| 7. do. Cat. No. 61.4238 (♂) | 78 " | 60 " | 21 " |

Outside of Pennsylvania this species grows much larger.

*Soft parts:* Figured by Lefevre & Curtis, 1910, Pl. 1, fig. 6, and 1912, Pl. 6, fig. 3; described by Ortmann, 1912, p. 282. *Glochidia* (See Lea, Obs. VI, 1858, Pl. 5, fig. 29; Lefevre & Curtis, 1910, p. 97, fig. A, and 1912, p. 146, fig. A; Ortmann, 1911*b*, Pl. 89, fig. 11; Surber, 1912, Pl. 1, fig. 6. Lefevre & Curtis give the dimensions: 0.28 × 0.30 mm.; Surber: 0.310 × 0.320; while I gave: 0.34 × 0.34 mm.

*Breeding season:* I found gravid females on September 14, 1909; September 22, 1910; and May 14, 1908. Glochidia were observed on the first and last dates. Although these records are very meager, yet they distinctly indicate that we have to deal with a bradytictic form, which carries the glochidia over winter. According to Surber (1912, p. 7), this species is gravid in October, November, and May.

*Remarks:* An extremely characteristic species, which in its external shape greatly resembles *Proptera alata* (Say), but may be distinguished at once by the color of the nacre (white, not purple), by the hinge, and some minor characters. The similarity of the outer shape of these two species, belonging to different subfamilies, is very remarkable, and offers a very good example of parallel, but independent, development of the same external characters ("convergency").

Aside from slight differences in outline and the variability of the hinge, this species varies chiefly in the development of the sculpture of the posterior slope. In Pennsylvania both conditions, specimens with well-developed sculpture, and with practically smooth shells, are found side by side, accompanied by all transitional stages. In size the Pennsylvanian shells remain far below the dimensions recorded for specimens from farther west (Scammon gives: L. 188; H. 110; D. 52 mm.).

*Localities in Pennsylvania represented in the Carnegie Museum:*

Conneaut Outlet, Conneautlake, Crawford Co.
Leboeuf Creek, Waterford, Erie Co.

*Other localities represented in the Carnegie Museum:*

*Lake-drainage:*

St. Josephs River, Fort Wayne, Allen Co., Indiana (C. Goodrich).

*Ohio-drainage:*

Ohio River, Wheeling, Ohio Co., West Virginia (W. F. Graham); Portland, Meigs Co., Ohio.[86]
Wolfe Creek, Wolfe Creek P. O., Washington Co., Ohio (W. F. Graham).
West Fork White River, Riverside, Green Co., Indiana (J. D. Haseman).
Wabash River, New Harmony, Posey Co., Indiana (A. A. Hinkley).
Middle Island Creek, Union Mills, Pleasants Co., West Virginia.
Pocatalico River, Raymond City, Putnam Co., West Virginia.

*West of Mississippi:*

Roché-Perché Creek, Columbia, Boone Co., Missouri (D. K. Greger).
Kansas River, Lawrence, Douglas Co., Kansas (R. L. Moodie).
Solomon River, Salina, Saline Co., Kansas (R. L. Moodie).
Black River, Black Rock, Lawrence Co., Arkansas (H. E. Wheeler).
Chikaskia River, Tonkawa, Kay Co., Oklahoma (F. B. Isely).

*Alabama-drainage:*

Big Prairie Creek, Hale Co., Alabama (Dr. Showalter, Hartman collection).
Cahaba River, Gurnee, Shelby Co., Alabama (H. H. Smith).

*Distribution and Ecology* (See fig. 12): *Type-locality*, Fox River, Wisconsin (Barnes).

The distribution of this species in Pennsylvania is very remarkable. It is found only in two places; in both in the outlet of a glacial lake. At Conneaut Outlet I found this species in rather strongly flowing water, with a soft bottom of muddy sand; in Leboeuf Creek in a soft shell-marl. At both places the size of the stream is about the same, rather small, with the supply of water uniform, regulated by the lake above.

While at both localities the species is quite frequent, no trace of it has ever been found in any other stream in this state. Down the Ohio, it turns up for the first time at Wheeling, and further down at St. Marys, Parkersburg, and Portland. But at St. Marys it is not in the Ohio proper, but in the slackwater of Middle Island Creek, which goes up about five miles (to Union Mills). In the Kanawha-drainage it goes up to Pocatalico River, in the lower part of which it is not rare, being chiefly found in quiet and muddy pools.

*L. complanata* has been reported to prefer deep and quiet water with muddy bottoms (Baker, 1898*a*, Call, 1900, Scammon, 1906) although Scammon mentions that it is occasionally found in riffles and in gravel. I have found it under such conditions in the smaller branch of the Ohio at Portland, but only a single individual. The lack in Pennsylvania of the environment it prefers accounts for its absence in the upper Ohio-drainage in general. So much more astonishing is its presence in the outlets of two glacial lakes, and I am not prepared to say, which

[86] I have also seen dead shells at Parkersburg, Wood Co., West Virginia, in the small branch of the Ohio at Neal Island.

are the environmental features, which have favored its establishment there. Furthermore the question remains to be answered how it succeeded in reaching these isolated stations.

With regard to this phenomenon, attention may be called to the fact that this species, although distributed over the whole state of Ohio (Sterki, 1907*a*), is especially found in its northeastern part, not far from the Pennsylvanian localities. Dean reports it from Mahoning River;[87] Silver Creek, Portage Co.; and from Cuyahoga River (lake-drainage). It seems that there might be here a connection with the Pennsylvanian localities, and then this species very likely would belong in the same category as *Lasmigona viridis* (see above).

This species has a very wide distribution, and is found according to Simpson (1900) in the "upper Mississippi-drainage as far south as Arkansas in the west; Ohio River-system; upper St. Lawrence and its tributaries, north into Mackenzie River." A number of localities are known in the Lake Winnipeg and Nelson drainages; in Lake of the Woods belonging to the upper Lakes drainage. It occurs also in Michigan (Walker, 1898) in the lake-drainage, and in Rouge River at Detroit belonging to the Lake Erie-drainage. It is found in the Erie-drainage in Indiana and Ohio (Goodrich, 1914, Dean), but it has never been reported from Lake Erie proper (Walker, 1913, p. 22). A record from Buffalo cannot be credited on account of the general inaccuracy of this list, and Call's "western New York" remains unconfirmed (Marshall, 1895). In addition, it goes southward into the Alabama-drainage, according to Call (1885) and Lewis (1877) (See also specimens in Carnegie Museum). Strangely enough localities from South of the Ohio in Kentucky and Tennessee are not known, except the record of Wilson & Clark (1914) from the Cumberland in Tennessee. Apparently, the Alabama localities are connected with the rest of the range not in a northerly, but in a westerly direction. The species is found in northern Louisiana (Marshall, 1895; Vaughan, 1893). It extends westward to Iowa, Kansas, Arkansas, and Oklahoma.

*Note:* SIMPSONICONCHA AMBIGUA (Say) (1825).
*Hemilastena ambigua* (SAY) SIMPSON, 1914, p. 325.[88]

This species has never been found in Pennsylvania. According to Simpson it is distributed in the "Ohio River system; north to Michigan; west to Iowa; south to Arkansas; east to Tennessee." According to Dean (1890), it is rare in the Mahoning River, Ohio, but I have hunted for it in vain in the Pennsylvanian part of this river.

[87] No trace of it in the Pennsylvanian part of this river.

[88] As to the generic names *Simpsonaias* and *Simpsoniconcha*, see Frierson, 1914*a*, p. 7, and 1914*b*, p. 40.

On May 23, 1912, I found a single specimen of this species in the headwaters of the Monongahela in West Fork River, Lightburn, Lewis Co., West Virginia. I found it buried deeply in sand and gravel held together by the rhizomes and roots of *Dianthera*.

Being thus present in two rivers, which run into our state, it might have once existed here, or else it accidentally may have escaped detection.

The systematic position of this genus is as yet quite uncertain. The account of the anatomical structure given by Simpson is quite unsatisfactory, in fact partly unintelligible. Besides the nomenclature of the genus requires final adjustment.

## Genus Anodonta Lamarck (1799).

Ortmann, 1912, p. 286; Simpson, 1914, p. 358.

Type *Mytilus cygneus* Linnæus.

A large number of species of this genus are known, many of which may be only special phases of others. In Pennsylvania, four species and one or two varieties may be distinguished, but I am not sure whether all of them are "good species."

### Key to the Species and Varieties of Anodonta in Pennsylvania.

$a_1$. Umbonal region convex, or more or less inflated and elevated above the hinge-line. Beak-sculpture consisting of several rather strong, double-looped bars, which generally have a sharp re-entering or angular sinus. Gonochoristic.

- $b_1$. Beak-sculpture rather heavy, forming distinct nodules on the posterior loop.
  - $c_1$. Shell rather compressed, not swollen.
    - $d_1$. Shell not very thin, ovate, somewhat elongate.......... *A. grandis.*
    - $d_2$. Shell rather thin, large, higher and shorter.......... *A. grandis gigantea.*[89]
  - $c_2$. Shell more swollen and inflated, chiefly in the umbonal region.......... *A. grandis footiana.*
- $b_2$. Beak-sculpture less heavy, generally not nodulous, and bars of uniform thickness.
  - $c_1$. Shell rather thin or moderately thick, not thickened along the lower anterior margin. *A. cataracta.*
  - $c_2$. Shell somewhat thicker, and especially so along the lower anterior margin..... *A. implicata.*

$a_2$. Umbonal region remarkably depressed and flattened, and not elevated above the hinge-line. Beak-sculpture consisting of several delicate, irregular bars, with a slight tendency to fall into two loops, the sinus being a mere notch. Hermaphroditic.......... *A. ohiensis.*

[89] I shall not treat this as a "variety." It has been introduced here only to bring out its characters.

### Anodonta grandis Say (1829).

*Anodonta grandis* Say; Simpson, 1914, p. 418.

Plate X, figs. 1, 2.

*Records from Pennsylvania:* [90]

Ortmann, 1909*b*, p. 195. It is very remarkable that this common species has never before been reported from western Pennsylvania.

*Characters of the shell:* Shell large, sometimes very large, but generally rather light and thin, often very thin. Outline subovate or subelliptical, more or less elongate, rounded anteriorly, more or less narrowed behind, often somewhat pointed. Lower margin more or less convex, upper margin straight, often forming an angle with the obliquely descending posterior margin, which in many cases forms a moderately developed wing, but in other cases may be altogether absent. Young shells are often symphynote at the upper posterior angle. Beaks slightly swollen and moderately convex, somewhat elevated above the hinge-line, placed more or less anterior to the middle of the shell. Beak-sculpture (Marshall, 1890, figs. 15, 18, as of *A. lewisi*) normally distinct and rather heavy, consisting of four to five (rarely six) bars, of which the first and second are concentric, while the following are distinctly double-looped, with a sharp re-entering sinus between the loops. The anterior loop is broadly rounded, while the posterior is angular, narrower, and characteristically elevated, so as to form a distinct tubercle. However, there is great variability in the beak-sculpture, chiefly with regard to the development of the sinus and the tubercle. The former may be shorter or longer, often so long as to reach the preceding bar; often the bar is weak at the sinus, so that a notch is formed, the anterior and posterior loop being higher than this part. The tubercles may be more or less distinct, and sometimes also the posterior end of the anterior loop (close to the sinus) is tubercular, so that a double row of tubercles appears to be present, radiating from the beaks. In partly eroded beaks, often only the tubercles are preserved.

Shell gently swollen in the middle and toward the beaks, but swelling very variable, sometimes rather flattened on the disk. Posterior ridge indistinct, greatest diameter of the shell about the middle. Posterior slope slightly compressed, often elevated and winged at the upper posterior angle.

Epidermis yellowish, greenish, to brownish and blackish. Rays indistinct as a rule; in large specimens (and often also in younger ones), there is no trace of rays on the disk. In other cases there are traces of green rays, but they are never very distinct, and, when present, generally obliterated by the concentric color-

[90] Simpson (1900, p. 644) gives, with ??, southeastern Pennsylvania, but this is surely incorrect.

pattern. The latter consists of concentric bands of lighter and darker color, largely corresponding to growth-periods. Upon the lighter bands the rays are sometimes visible. However, very often there are one to three more distinct, dark green to black rays upon the posterior slope, which are best visible in transmitted light. In many specimens, chiefly in the common creek-form, the epidermis is uniformly blackish.

Hinge edentulous, forming a practically straight line, with only the faintest trace of a light undulation under the beaks. Beak-cavity shallow or moderate. Dorsal muscle-scars faint, situated in the beak-cavity. Nacre white, as a rule, silvery, bluish white, or cream-color, rarely pinkish, generally highly iridescent, with blue, purple, and greenish reflections. In some cases it is more distinctly reddish (salmon to rusty), but this is pathological (see below under *salmonia*).

There is a difference in the shape of the shell of the two sexes, but this is very slight, and not always present. In the females, and chiefly in the larger ones, the shell is more swollen in the posterior middle portion of the disk, just in front of the indistinct posterior ridge, in the region where the marsupium is located. This swelling sometimes renders the lower margin more curved and slightly prominent behind the middle. In extreme cases the shell is even slightly depressed in front of the swelling. In young and half-grown shells this shape is not noticeable, and even older shells do not always show it. Where it is distinctly developed, it can be safely taken for an indication of the female sex, but not all females have this character. It also should be said, that in the typical (creek-) form, this sexual difference is much less evident, than in the form of quiet water (*gigantea*).

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Linesville, Cat. No. 61.845 (largest on hand) | 128 mm. | 70 mm. | 44 mm. |
| 2. Edinboro, Cat. No. 61.3648 (♀ gravid) | 126 " | 62 " | 44 " |
| 3. Waynesburg, Cat. No. 61.4729 (♀) | 123 " | 68 " | 40 " |
| 4. Cochranton, Cat. No. 61.3661 (♀ gravid) | 118 " | 68 " | 39 " |
| 5. Jamestown, Cat. No. 61.3659 (♂) | 105 " | 61 " | 41 " |
| 6. Waynesburg, Cat. No. 61.4729 (♂) | 91 " | 52 " | 33 " |

*Soft parts* (See Ortmann, 1912, p. 292). *Glochidia* figured by Lea, Obs. VI, 1858, Pl. 5, figs. 32–34 and Surber, 1912, Pl. 3, fig. 45. Surber's measurements are: $0.41 \times 0.42$, while I gave: $0.36 \times 0.37$ mm.

*Breeding season:* Gravid females have been frequently found from August 6 to November 12, and again on May 22. This species seems to discharge very early in spring (April). May 22 seems to be an exceptionally late date.

*Remarks:* This is a very variable species, for which a great number of specific names has been introduced, chiefly by Lea. The typical form (of which *ovata*

Lea, *lewisi* Lea, *salmonia* Lea, *harpethensis* Lea simply are synonyms) is a shell preferably inhabiting small creeks. It is chiefly characterized by its rather elongated, subovate shape, with rather flat valves, by the comparative solidity of the shell, its dark (greenish to blackish) color, and the nodulous character of the beak-sculpture. The posterior end of the shell generally is narrowed, and the posterior point is moderately elevated above the base line; and there is hardly a wing (however, this is sometimes indicated in the young). Yet all these characters are variable, and certain extreme forms are found under peculiar conditions of environment, so that they are to be regarded as ecological variations, which turn up, within the range of the species, wherever the proper conditions are found. A number of them have received names; but these names should not be used as varietal names, since the forms designated by them have no defined geographical areas. They certainly are not "subspecies" in the strict taxonomic sense. I shall mention here some of these "forms," as far as they are found in Pennsylvania, with the express understanding, that I regard them only as individual variations, or at the utmost as special reactions to peculiar environmental conditions, which are not regionally restricted.

*Anodonta grandis* forma *salmonia* (Lea) (Obs. II, 1838, Pl. 14, fig. 41).

This is an unqualifiedly typical *grandis,* with the nacre peculiarly discolored (reddish, from pale salmon to deep rusty red), and at the same time the nacre becomes rough by the formation of small pustules and granulations. That this is due to an infection by a parasite (a distomid) is now generally conceded (see Wilson & Clark, 1912*a*, p. 47), and consequently the name *salmonia* has no taxonomic standing, and might better be entirely dropped.

In Pennsylvania, such diseased forms are rather frequent in the northwestern corner of the state (headwaters of Beaver system, and small tributaries of the upper Allegheny), but are absent in the southwestern section. Sometimes traces of this disease are found in pond- and lake-forms. At certain localities, practically all individuals are more or less infected with this parasite.

*Anodonta grandis* forma *gigantea* (Lea) (1834) (Simpson, 1914, p. 420).

This is the form found in small, muddy pools, where it lives deeply buried in black muck. It is distinguished from the creek-form by its larger size, thinner, and higher and less elongated shell, and generally by more vivid color (yellowish and greenish concentric bands, and more distinct traces of rays). However, this form also is very variable, even in the same pond, and it passes insensibly into the creek-form. In ponds more elongated specimens are often found, and in creeks specimens from quiet and muddy pools distinctly incline toward the pond-form. Specimens from ponds often also possess a rather thick shell.

This form is rather scarce in Pennsylvania. My supply of it comes chiefly from a pond (old branch of Allegheny River) at Harmarville, Allegheny Co. But other specimens are at hand from an artificial ice pond at Edgeworth, Allegheny Co., and from a pond at Idlepark, Westmoreland Co., formed by the cutting off of a part of Loyalhanna River by the railroad. Probably this form will turn up in other ponds of the western part of the state.

| | | | | | L. | H. | D. | |
|---|---|---|---|---|---|---|---|---|
| *Size:* 1. | Harmarville, | Cat. | No. | 61.4742 (♂) | 149 mm. | 90 mm. | 51 mm. | (largest) |
| 2. | do. | " | " | 61.3667 (♀ gravid) | 148 " | 88 " | 56 " | |
| 3. | do. | " | " | 61.4742 (♂) | 116 " | 68 " | 49 " | |
| 4. | do. | " | " | do. (♀ gravid) | 109 " | 66 " | 40 " | |
| 5. | do. | " | " | do. (♂) | 107 " | 64 " | 43 " | |
| 6. | do. | " | " | do. (♂) | 93 " | 58 " | 31 " | |

Comparing these measurements with those of the creek-form, given above, it is clearly seen that this form stands very close to the type, but grows larger, and is relatively somewhat shorter and higher. It also is distinctly thinner in the shell. It is in this form, that I have best recognized the sexual differences of the shell.

In addition there are other local forms in our region, and such are found chiefly in the lakes of the glacial area in northwestern Pennsylvania. The following deserve special mention; but should not bear distinct names, since they are only special reactions to special environment, and probably entirely inconstant.

*Conneaut-lake-form A.* Resembles in shape and the thin shell the form *gigantea*, but is only half as large, and the epidermis has a peculiar light green to pale brown color. I have only a few specimens, which I collected on gravelly bottom on the north east shore of Conneaut Lake in from three to four feet of water.

*Conneaut-lake-form B.* Like form A in color (light green), but much more elongated and subelliptical (not subovate). This form in shape looks almost like *A. marginata* Say (= *lacustris* Lea), but traces of the beak-sculpture of *grandis* are plainly seen. I have only a single specimen, which was collected by Mr. D. Stewart, and I do not know particulars about the ecological conditions, except that it comes from somewhat deeper water. L. 58 mm., H. 32 mm., D. 17 mm.

*Conneauttee-lake-form.* A much elongated form, like form B of Conneaut Lake, with very thin shell, but epidermis darker, green to brownish black. As in form B from Conneaut Lake, the beaks appear much anterior in consequence of the posterior elongation of the shell. The typical *grandis*-sculpture of the beaks is well developed.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. | 115 mm. | 55 mm. | 39 mm. |
| 2. | 76 " | 40 " | 22 " |
| 3. | 50 " | 25 " | 15 " |

I obtained five specimens of this form in the black muck of Conneauttee Lake, Edinboro, Erie Co. In the outlet of the lake (Conneauttee Creek) the creek-form of *A. grandis* was more or less typically developed.

Finally, it should be mentioned, that there are often specimens among typical *A. grandis*, which are more swollen, thus approaching the var. *footiana* (to be discussed below). Such specimens sometimes are rather frequent at certain localities, chiefly so in the uppermost Shenango River, at Linesville, Crawford Co., and these forms are truly transitional toward var. *footiana*. It also should be emphasized that the form in Conneaut Creek, at West Springfield, Erie Co. (tributary to Lake Erie) is the typical creek-form of *A. grandis*.

*Anodonta grandis* behaves in Pennsylvania exactly as elsewhere. Over the wide range of this species we have a great tendency to form local races and ecological forms, which in many cases have received names of their own, without

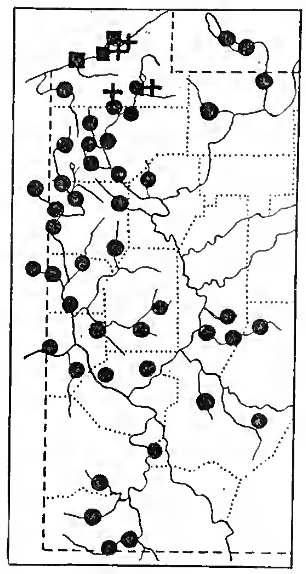

FIG. 14.

● *Anodonta grandis*.
■ *Anodonta grandis footiana*.
+ *Anodonta ohiensis*.

deserving them. I cannot go further into detail, since my material of the extralimital forms is not at all sufficient. But it is clearly seen that in Pennsylvania as elsewhere this species is protean, accommodating itself to a variety of conditions, and assuming different characters in shape and thickness of shell, in color, and in size. It does not seem to reach in our state the extreme size recorded from other parts (Baker, 1898*a*, p. 53, L. 171 mm.). However, one character generally

remains constant, or varies only within narrow limits, that is the beak-sculpture, which in well-preserved individuals is always double-looped and tubercular.

*Localities in Pennsylvania represented in the Carnegie Museum:*

*Ohio-drainage:*

Smiths Ferry, Beaver Co. (D. A. Atkinson).[91]
Raccoon Creek, New Sheffield, Beaver Co.
Ice pond, Edgeworth, Allegheny Co. (G. H. Clapp) (forma *gigantea*).
Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).[92]
Brush Creek, Celia, Beaver Co.
Glade Run, Zeno, Butler Co.
Bonnie Brook, East Butler, Butler Co.
Wolf Creek, Grove City, Mercer Co.
Mahoning River, Hillsville, Lawrence Co.
Neshannock Creek, Volant, Lawrence Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Shenango River, Sharpsville, Shenango, and Jamestown, Mercer Co.; Linesville, Crawford Co.

*Allegheny-drainage:*

Pond, Harmarville, Allegheny Co. (forma *gigantea*).
Beaver Run, Delmont, Westmoreland Co.
Pond, Idlepark, Westmoreland Co. (D. A. Atkinson) (forma *gigantea*).
Crooked Creek, Rosston and Southbend, Armstrong Co.; Creekside, Indiana Co.
Cowanshannock Creek, Rural Valley, Armstrong Co. (N. M. Grier).
Sandy Creek, Sandy Lake, Mercer Co.
French Creek, Cochranton, Meadville, and Cambridge Springs, Crawford Co.
Sugar Creek, Cooperstown, Venango Co. (E. P. Spencer).
Conneaut Outlet, Conneautlake, Crawford Co.
Conneaut Lake, Crawford Co. (special forms, see above).
Cussewago Creek, Mosiertown, Crawford Co. (H. & L. Ellsworth).
Conneauttee Creek, Edinboro, Erie Co.
Conneauttee Lake, Edinboro, Erie Co. (special form, see above).
Leboeuf Creek, Waterford, Erie Co.
Brokenstraw Creek, Garland, Warren Co.
Connewango Creek, Russell, Warren Co.

*Monongahela-drainage:*

Monongahela River, Westmoreland Co. (G. A. Ehrmann).
Ten Mile Creek, Amity, Washington Co.
South Fork Ten Mile Creek, Waynesburg, Greene Co.
Dunkard Creek, Wiley and Mount Morris, Greene Co.

[91] Not recorded upon the label whether from the Ohio or from Little Beaver Creek, probably from the latter.

[92] Rhoads (1899) does not give this species from Wampum, and H. H. Smith also apparently overlooked it, since the specimen, upon which our record is founded, was discovered among duplicates of *Strophitus edentulus*.

*Lake Erie-drainage:*

Conneaut Creek, West Springfield, Erie Co.

*Other localities represented in the Carnegie Museum:*

*Lake-drainage:*

Black Creek, Chili, Monroe Co., New York (R. H. Santens).
Creek at North Fairfield, Huron Co., Ohio (O. E. Jennings).[93]
Ten Mile Creek, Lucas Co., Ohio (C. Goodrich).[94]
Miami and Erie Canal, Waterville, Lucas Co., Ohio (C. Goodrich).
Maumee River, Toledo, Lucas Co., Ohio (C. Goodrich).
St. Marys River, Rockford, Mercer Co., Ohio (C. Goodrich).
Beaver Creek, Williams Co., Ohio (C. Goodrich).
Raisin River, Adrian, Lenawee Co., Michigan (C. Goodrich).
Big and Little Whitefish Lake, Pierson, Montcalm Co., Michigan (Miss M. O'Malley).[95]

*Ohio-drainage:*

Chautauqua Lake (R. Foerster): Bemus Point (D. R. Sumstine), Griffith Landing (Miss B. A. Ortmann), Celeron (P. E. Nordgren), Chautauqua Co., New York.[96]
Conotton Creek, New Hagerstown, Carroll Co., Ohio.
Tuscarawas River, Ohio (Holland collection).
Wolfe Creek, Washington Co., Ohio (W. F. Graham).
Redfield, Perry Co., Ohio (Juny collection).
Scioto River, Kenton, Hardin Co., Ohio (C. Goodrich).
Lewistown Reservoir, Logan Co., Ohio (C. Goodrich) (head of Big Miami).
Wabash River, Fort Recovery, Mercer Co., Ohio (C. Goodrich).
Gravel pit, near Bluffton, Wells Co., Indiana (E. B. Williamson).[97]
Winona Lake, Kosciusko Co., Indiana (E. B. Williamson) (Mrs. E. Courtney).[98]
West Fork River, Lynch Mines, Harrison Co.; Lightburn and Weston, Lewis Co., West Virginia.
Little Kanawha River, Burnsville, Braxton Co., West Virginia.
North Fork Hughes River, Cornwallis, Ritchie Co., West Virginia.
Licking River, Farmer, Rowan Co., Kentucky.
Fleming Creek, Pleasant Valley, Nicholas Co., Kentucky.

[93] Intergrading toward var. *footiana*.

[94] Intergrading toward var. *footiana*.

[95] A form, compressed like typical *grandis*, but having a peculiar, light-colored epidermis.

[96] I have many specimens, all representing a peculiar local race, greatly resembling *A. benedictensis* Lea; small (maximum L. 90 mm.), and not quite as short as *benedictensis*. Most specimens much abraded upon posterior slope. Color light green to light brown, but not blackish. Beak-sculpture of typical *grandis*-character. Call (1885) reports *A. footiana* from this lake, but my specimens are *not* this.

[97] Intergrading toward var. *footiana*.

[98] A special form resembling *gigantea* in outline, but rather swollen, like *footiana*, and with the beak-sculpture of typical *grandis*. Epidermis light greenish to brown. One specimen almost like specimens from Tippecanoe Lake, recorded below under *footiana*. Call (1900) gives *footiana* from Eagle (= Winona) Lake; Norris (1902) records *grandis* from Winona as well as Pike and Center Lakes, and does not mention *footiana*.

*Tennessee-drainage:*

Mountain Fork Flint River, New Market, Madison Co., Alabama (H. E. Wheeler).[99]

*Western and southwestern localities:*

Flat Creek, Sedalia, Pettis Co., Missouri (W. J. Utterback) (typical!).

Wakarusa River, Lawrence, Douglas Co., Kansas (R. L. Moodie) (typical!).

Sabine River, Logansport, De Soto Parish, Louisiana (L. S. Frierson).[100]

Lake Providence, East Carroll Parish, Louisiana (Juny collection).[101]

The Carnegie Museum possesses additional material, chiefly from southern and southwestern localities, but these are local forms or races, with which I am not familiar, and so I do not discuss them here. There are specimens at hand from the Alabama-drainage, in part labeled *A. hallenbeeki* Lea by Walker. They are very close to *A. grandis,* and if they are actually *hallenbeeki,* this name should also probably become a synonym of *A. grandis.*

*Distribution and Ecology in Pennsylvania* (See fig. 14): As has been mentioned above, the typical *A. grandis* is a form characteristic of smaller creeks. It decidedly avoids the larger rivers, and is not found at all in the Ohio and Allegheny, and from the Monongahela only a single individual is on record. This holds good also farther down the Ohio. In the tributaries, however, it is not rare, and becomes most frequent in the smaller headwaters.

In these creeks it prefers quiet pools and eddies, often below riffles, where it sticks in fine sand and mud. Occasionally it is found in riffles, but then probably washed out of deeper and more quiet places. Yet it is to be seen that the typical form by its somewhat stronger shell is adapted to a stronger flow of water, since even in the quiet pools of small streams a stronger current may prevail during periods of high water.

Under these conditions this species is found rather uniformly over western Pennsylvania, and goes eastwards to Warren, Indiana, and Westmoreland Cos. But it is also capable of living in rather different surroundings, namely in ponds and lakes. But we have seen that special forms develop under these conditions. However, with the exception of a few glacial lakes, this environment is not often found in western Pennsylvania, and there is a remarkable lack of ponds in the southwestern part of the state. Thus the pond forms are rather scarce in our region, as may be seen from the records given above, and we notice that they often turn up in isolated ponds (Harmarville, Edgeworth, Idlepark), where there is apparently no connection with streams inhabited by it. This has been observed

[99] A large, thick-shelled form, corresponding wonderfully well with Lea's original figure of *gigantea* (Obs. II, 1838, Pl. 1, fig. 1).

[100] A specimen absolutely indistinguishable from typical creek-forms of Pennsylvania, possibly not quite as thick-shelled as the average.

[101] Very much like the typical *gigantea.*

elsewhere, and its presence in such ponds can be explained only by the assumption, that exceptional means of dispersal are available, presumably transport by aquatic birds. This is also suggested by its distribution across the northwestern section of our state, where it seems as if it had gone across country, not following the streams. This, however, requires further investigation. It should also be pointed out that it is very remarkable that these factors, if acting at all, did not act in an eastward direction across the Alleghenian divide; and that this species is entirely missing in the Atlantic-drainage, although it approaches the divide very closely in Indiana and Westmoreland Cos. But this holds good only for Pennsylvania, and is different in New York (see below).

*General distribution: Type locality,* Fox River of Wabash River, Indiana (Say). According to Simpson (1900, p. 644),[102] the range covers the "entire Mississippi system; the upper St. Lawrence-drainage; Red River of the North; Lake Winnipeg; Manitoba; southwest Texas" (he also with doubt mentions southeastern Pennsylvania, but this should be cancelled). This is certainly a correct general statement. But the exact boundaries of this species are yet largely ill-defined. In western Pennsylvania we apparently have part of the northeastern boundary of the range, and it here coincides practically with the divide between the interior basin and the Atlantic-drainage. However in New York state this is different, for here this species passes over into the Atlantic-drainage of the Hudson as well as the St. Lawrence River (see DeKay, 1843; Dewey, 1856; Marshall, 1895; Baker, 1898*b*). In part in its eastward advance, it seems to have used the route of the Erie canal, reaching Albany County, and has here invaded the territory of the eastern *A. cataracta.* Its relation to this latter species in this region (western and central New York) has never been closely studied, and on account of the great resemblance of these two species it is very likely that they have often been mistaken for each other. In this region *A. grandis* (generally known under the name of *A. lewisi*) is found chiefly in streams and in some smaller lakes, and it does not go into the large lakes. The same seems to be true all along the northern boundary of its range, and, as soon as the great lakes are reached, it turns into the var. *footiana.* In Pennsylvania, it goes up to the divide, and it is even in Conneaut Creek, a tributary of Lake Erie; but it is *not in* the lake.

Generally in the region of the divide, intergrades are found between the two varieties. Farther south *grandis* prevails, and finally is the only form in existence.

[102] To Simpson belongs the credit of having reduced the number of species of *Anodonta* to reasonable limits, and he has to a large extent worked out the synonymy of this species; but I hardly think that he has gone far enough, and believe, that some "species" admitted by him, will finally fall as synonyms under *A. grandis.*

In the Tennessee-drainage it is extremely rare, but certainly extends into northern Alabama. It is also very rare in the Cumberland-drainage, but has been reported by Wilson & Clark (1914) from ponds at Clarksville, Montgomery, Tennessee, and from Stones River, in Rutherford Co., Tennessee.

In the southwestern part of its range this species seems to become more decidedly a pond- or lake-form. Call (1900) makes the statement that in Indiana it is found in the ponds along the Ohio and Wabash, and that it occurs in the rivers in the northwestern part of the state, that is to say, in smaller streams; this corresponds well with what we have observed in Pennsylvania. But west of the Mississippi pond-forms prevail, and assume special shapes, which I cannot discuss here, for they require much more detailed study (compare Wheeler, 1918, p. 121).

### ANODONTA GRANDIS FOOTIANA (Lea) (1840).

*Anodonta grandis footiana* (LEA) SIMPSON, 1914, p. 422.

Plate X, figs. 3, 4.

*Records from Pennsylvania:*

Ortmann, 1909*b*, p. 202.

*Characters of variety:* According to Baker (1898*a*, pp. 51 and 53), this variety differs from *Anodonta grandis* by the greater inflation of the shell, chiefly in the anterior and umbonal region, and by the finer beak-sculpture, which consists of only four bars (while there are five in *A. grandis*).

This is the most concise statement of the differences of the two forms that has ever been made. But with regard to the number of the bars in the beak-sculpture it is to be remarked that in the light of my material, this is quite variable (from four to six bars in *footiana* as well as *grandis*), but with a stronger tendency toward the smaller figure in *footiana*.

In other respects *A. grandis footiana* behaves much like *A. grandis*, and varies greatly in shape (more or less elongated), thickness, and color (from yellowish and greenish to brownish and reddish); it lacks the dark green and blackish tints found so often in *grandis*. Rays are generally entirely missing. The size is inferior to that of *grandis*.

| | L. | H. | D. | |
|---|---|---|---|---|
| *Size:* 1. Beach Pool G., Cat. No. 61.4182 | 122 mm. | 65 mm. | 48 mm. | (largest at hand) |
| 2. do. " " do. | 115 " | 57 " | 45 " | long form. |
| 3. do. " " do. | 100 " | 52 " | 38 " | long form. |
| 4. Beach Pool E. & F., Cat. No. 61.4181 | 98 " | 53 " | 41 " | long form. |
| 5. do. " " do. | 95 " | 49 " | 37 " | long form. |
| 6. "Big Bend," Cat. No. 61.4188 | 107 " | 67 " | 43 " | short form. |
| 7. do. " " do. | 93 " | 53 " | 37 " | short form. |

*Soft parts:* As far as studied, identical with those of *A. grandis,* but gravid females have never been found, and thus the *glochidia* and the *breeding season* are unknown. However, the fact that the specimens, collected in May, June, and July, were not gravid, indicates that the "interim" falls in these months, as is the case in *A. grandis,* and thus probably the breeding season will be about the same.

*Remarks:* I regard this as a geographical race of *A. grandis,* which replaces the latter in the St. Lawrence-drainage, and chiefly in the Great Lakes. It is, however, not a "good species," for south of the lakes, and passing somewhat beyond the divide, into the Ohio-drainage, there is a region, where true intergrades are found (in Pennsylvania, Ohio, Indiana, and Illinois). Some of these intergrades, standing nearer to *grandis,* have been recorded under *grandis* (see above). And further, even in Lake Erie, the form *footiana* does not always preserve its typical characters, becoming sometimes more flattened (specimens from the lagoon at Waldamer Park, and from ponds at mouth of Elk Creek, and occasionally elsewhere), and having heavier beak-sculpture.

As regards the beak-sculpture, it is essentially of the *grandis*-type in so far as it consists of four or five (sometimes six) bars, of which the third to the sixth are distinctly double-looped, the loops separated by a sharp, re-entering sinus. Within this sinus the bar is generally lower, sometimes almost effaced, so that it represents a notch, on either side of which the anterior and posterior loop appear elevated.[103] However, the posterior loop of *footiana,* which has the same angular and narrow shape as in *grandis,* is not so much thickened, and is not so distinctly tuberculiform, and altogether the beak-sculpture is less heavy, finer, and sharper than in *grandis.* The notch-like shape of the sinus, forming generally an interruption of the bar, shows that this form should be placed under *A. grandis,* although by the delicacy of the sculpture it distinctly inclines toward *A. cataracta.*

In Lake Erie (in Pennsylvania), *A. grandis footiana* shows two extremes of development of the shape of the shell, which are connected, however, by intergrades, and are, according to my observations, distinctly dependent on the ecological conditions under which they live.

*The most abundant form* (among my material) is rather elongated, and closely corresponds in the general outline to Lea's *maryattana* (Obs. III, 1842, Pl. 20, fig. 45), but it is not so excessively and abruptly swollen. In its typical development this form is also characterized by a thin shell, and a peculiar, rusty-brown color, which is especially intense at and near the umbos, passing into brownish

[103] In some cases, the fifth, and chiefly the sixth bar (if this is present) have the sinus less sharp, resembling only an undulation: this is a variation, which I have never distinctly observed in *A. grandis.*

and yellowish brown toward the lower margin (alternating according to the growth-periods). There is no, or very little, green present, and the rays upon the posterior slope, if visible at all, are brownish black. According to my experience this form is characteristic of the lagoons and beach-pools of Presque Isle, where it is quite abundant, and very uniform in character.

*The other form* is less elongated, higher and shorter, sometimes squarish, with a very straight hinge-line, having a sharp anterior and posterior angle. Its shell is generally more solid, and its color is distinctly greenish, often rather light green, but passing into light brown, rarely into rusty. Its growth-rests are distinct and rather regular, and the rays upon the posterior slope are dark green. This is the form prevailing in Presque Isle Bay, chiefly on its north-shore, so called "Big Bend." Some of these short, squarish forms resemble to a degree *A. benedictensis* Lea (Obs. I, 1834, Pl. 16, fig. 48; and DeKay, 1843, Pl. 18, fig. 235), but I do not think they should be called by this name,[104] for there are intergrades with the elongated form of the beach-pools. These intergrades are frequently found associated with the normal (quadrate) form, and do not have the quadrate shape, but are more or less subovate, much resembling the original figure of Lea's *footiana* (Obs. III, 1842, Pl. 20, fig. 44). The specimens collected in ponds at the mouth of Elk Creek are all of this subovate form, with the typical *footiana* outline, and at the extreme western end of Presque Isle Bay in quiet and rarely disturbed water this ovate form is also present. In the lagoon at Waldamer Park I found specimens, which are more elongated, and thus approach the beach-pool form, but they have green (not rusty) epidermis.

It is evident that the squarish, thick-shelled form of the surf-beaten northern shore of Presque Isle Bay passes gradually into the elongated, thin-shelled form of the lagoons and beach-pools; and that it should be regarded as an ecological variation of *A. grandis footiana* (with which it agrees in the inflated beaks), and not as a form of *benedictensis*.

The various forms of *footiana* are distinguished from *A. cataracta* by the swollen and inflated beaks. Although *cataracta* has sometimes a rather inflated shell, the beaks are always low, and not so prominent as in *footiana*.

[104] *A. benedictensis* comes originally from Lake Champlain, and has been reported from other lakes in New York. The Lake Chautauqua-form of *A. grandis*, mentioned above, might be regarded as a dwarf form of it, and also the form from Lake Erie (Sterki, 1907*a*, p. 394; Walker, 1913, p. 22). Mr. Walker (according to a communication in a letter) considers the quadrate form and straight hinge-line as the chief characteristics of his *benedictensis*, and admits that this differs from the true *benedictensis* in being more inflated. All this fits the present form.

*Localities in Pennsylvania, represented in the Carnegie Museum:*

Lake Erie, Presque Isle Bay, and beach-pools of Presque Isle, and lagoon at Waldamer Park, Erie, Erie Co.

Pond at mouth of Elk Creek, Miles Grove (North Girard), Erie Co.

*Other localities represented in the Carnegie Museum:*

Lake Ontario, Braddock Bay, Manitou Beach, Monroe Co., New York (R. H. Santens).[105]
Lake Erie, Port Dover, Norfolk Co., Ontario, Canada (C. Goodrich).
Lake Erie, Sandusky Bay, Cedar Point, Erie Co., Ohio (O. E. Jennings) (normal).
Lake Erie, La Plaisance Bay, Monroe Co., Michigan (C. Goodrich) (young specimens).
Cedar Creek, Jerusalem Township, Lucas Co., Ohio (C. Goodrich).
Marsh, north of Toledo, Lucas Co., Ohio (C. Goodrich).
Miami and Erie Canal, Waterville, Lucas Co., Ohio (C. Goodrich).
Maumee River, Roche de Boeuf Rapids, Lucas Co., Ohio (C. Goodrich).[106]
Grand Reservoir, Mercer Co., Ohio (C. Goodrich).[107]
Silver Lake, Clark Co., Ohio (Hartman collection).[108]
Tippecanoe Lake, Kosciusko Co., Indiana (E. B. Williamson).[109]
Lake Huron, Port Huron, St. Clair Co., Michigan (N. M. Grier).
Black Lake, Muskegon Co., Michigan (Exch. Alabama Museum).
Big Bass Lake and Au Sable Lakes, Lake Co., Michigan (C. Goodrich).
Douglas Lake, Cheboygan Co., Michigan (H. B. Baker).
Muskoka Lake, Bala, Muskoka Co., Ontario, Canada (A. S. Daggette).
Lake Helen, Nipigon, Ontario, Canada (O. E. Jennings).
Lake Superior, Nipigon Straits, St. Ignace Island, Ontario, Canada (O. E. Jennings).
Blackwater River, Jellicoe, Ontario, Canada (O. E. Jennings) (Tributary of Lake Nipigon).
Long Lake, Longuelac, Ontario, Canada (O. E. Jennings).

In 1914, Dr. Jennings collected a form in Lake Nipigon (Orient Bay), which, in shape and beak-sculpture, is a true *A. grandis*, but has a peculiar rough epidermis. I have not yet been able to identify this.

*Distribution and Ecology* (See fig. 14): *Type locality,* Winnebago, Winnebago Co., Wisconsin (Lea).

In Pennsylvania this form is restricted to Lake Erie, and although individuals resembling it have been found in the uppermost Shenango, they were associated

[105] An interesting set of sixteen specimens, containing individuals inflated like typical *footiana*, some much more flattened, almost like typical *grandis*, with intermediate stages between these. Outline of the shell elongated-ovate, shorter or longer, like the creek-form of *grandis*, beak-sculpture more like *grandis*. Color light green to gray or brownish green. These are truly intergrades.

[106] A special (river-) form, heavy shelled, greenish, with rather heavy beak-sculpture. Considerably inflated at the beaks. A link in the chain of intergrades.

[107] Inflated like *footiana*, but in outline resembling the *gigantea* type.

[108] A typical elongate-subovate, greenish *footiana*. The specimen was labeled as given, but I cannot find a Silver Lake in Clark Co., but there are places of this name in Logan and Summit Cos.

[109] Wabash-drainage. A peculiar large form, resembling the form of *grandis gigantea* from Winona Lake, but more swollen, and with the beak-sculpture of *footiana*.

with typical *grandis*, and should be classed with them. In Lake Erie, this form is found, as has been stated, under various ecological conditions, but not in the open lake. It is present on the north shore of Presque Isle Bay, where there is, at times, a considerable surf, and lives here in from one to five feet of water. It has also been brought up by the "sand-sucker" from a depth of ten to fifteen feet. It prefers a bottom of pure sand or fine gravel, either bare, or covered with a growth of rushes (*Juncus americanus*). Many specimens on the north shore of the bay are much abraded, and apparently worn by the surf. Toward the western end of the bay, it is found upon the sandy "flats," among rushes, and at the extreme western end on a bottom, which consists of a mixture of sand and mud; in this section, the water is rather quiet, there is surf only during easterly winds, and this is broken and checked by the *Juncus americanus* formation, which runs far out into the bay. Further, this species in a special form inhabits the numerous lagoons and beach-pools of Presque Isle, which are rather shallow, and have a bottom of fine sand, often covered with more or less fine vegetable mud. It occurs also in the large and deep lagoon at Waldamer Park (base of Presque Isle), and I also found it in a pond cut off from the mouth of Elk Creek, on sandy-gravelly bottom. In Pennsylvania, this is distinctly a lake- and pond-form.

Lake Erie and the smaller lakes of the state of Michigan seem to be the metropolis of this form. The largest number of locality records are at hand from Michigan, due to the fine work of Walker (1898, see map of distribution, Pl. 1). Northwards it goes here as far as Chippewa Co. (Winslow, 1917) and Marquette Co. (South of Lake Superior), and Lake Gogebic, Ontonagon Co. (Ruthven). It is also in the lakes and bays of Isle Royale in Lake Superior (Walker, 1909, p. 294), and the Carnegie Museum possesses it from the region of Nipigon, on the North shore of Lake Superior. The most extreme locality in a northwestern direction is Souris River, Manitoba (Hudson Bay-drainage) (Dawson, 1875).

From Wisconsin it is known only from the type locality (Winnebago). Southward, it crosses over into the Mississippi-drainage in northern Ohio (Sterki, 1907*a*), northern Indiana (Call, 1896*a* and 1900),[110] and northern Illinois (Cook, Lake, Kane, McHenry Cos.) (See Baker, 1906, p. 73).

From Lake Erie eastwards and northeastwards, we have a number of records in western New York (Marshall, 1895), as far as Ottawa River, Canada (Call, 1885). However, some of these are doubtful, as for instance, Call's record from Chautauqua Lake, according to him the only locality in the Mississippi basin.

[110] As to *grandis* and *footiana* in Winona Lake (See footnote 98 on p. 144). Our specimens from this lake are nearer *grandis*. The form from Tippecanoe Lake in our collection is more like *footiana*; Wilson & Clark (1912*a*, p. 47) call this form: *grandis*, " of a more inflated type."

The form found in this lake, represented in the Carnegie Museum by numerous specimens, is a small race of *A. grandis*, possibly to be placed with *benedictensis*, but not with *footiana*.

*A. grandis footiana* belongs preëminently to the St. Lawrence system, and has a wide range in it. It crosses over into the Mississippi as well as the Hudson Bay drainages, but only very slightly, and in the former it intergrades with *A. grandis*.

### ANODONTA CATARACTA Say (1817).[111]

*Anodonta cataracta* SAY. SIMPSON, 1914, p. 386.

Plate X, fig. 5; Plate XI, fig. 1.

*Records from Pennsylvania:*

Haldeman, 1844 (Lancaster Co.).

Gabb, 1861 (Mill Creek, Milltown; Wissahickon Creek and Schuylkill River, Philadelphia, Germantown and League Island, Philadelphia Co.).

Lea, 1867 (Schuylkill, Delaware River, and League Island, Philadelphia) (*tryoni*).

Bruckhart, 1869 (Lancaster Co.).

Hartman & Michener, 1874 (Schuylkill River, Chester Co.).

Pilsbry, 1894 (York Furnace, York Co.).[112]

Schick, 1895 (Delaware and Schuylkill Rivers, Fairmont Park, League Island, Philadelphia; Germantown, and Canal at Manayunk, Philadelphia Co.; Munckinipattus Creek, Glenolden, Delaware Co.).

Marshall, 1895 (Tributaries of Genesee River, Potter Co.;[113] Juniata River).

Ortmann, 1909*b*, p. 205.

Caffrey, 1911 (Lehigh Canal and ponds, Bethlehem, Northampton Co.).

*Characters of the shell:* This species is very close to *A. grandis*, and the only reliable difference is in the beak-sculpture, and even this is a difference rather of degree of development than of type. The general character of the beak-sculpture is the same in both species (double-looped), but while in *A. grandis* the two loops are sharply separated by a sinus, which is generally depressed (notch-like), and while the posterior loop is tuberculiform, in *A. cataracta* the bars of the beak-sculpture, which are also slightly more numerous (five to seven) are uniform in elevation, and in the sinus they are not appreciably lower than in front and behind of it, so that no tubercles are formed. These differences have properly been pointed out by Marshall (1890, p. 188, 189). In the light of my material I have only to add, that the first two bars are simply concentric, and that those following are

[111] Not 1816, see p. 9.

[112] Pilsbry's (p. 30) " *A. subcylindrica* Lea " is this species. I have seen the specimens so labeled in the Philadelphia Academy of Natural Sciences.

[113] This locality should be confirmed.

double-looped, but in the last (sixth and seventh) the sinus is often not sharp, but represented merely by a gentle undulation. There is a good deal of variation, chiefly in the number of bars, but also in the sharpness of the sinus, which may be acute or more or less blunt.

In other characters the shells of the two species are much alike, but as a rule *A. cataracta* inclines more toward the elongated shape, although it also possesses comparatively short and high forms. In the elongated pond-forms, another difference is noted in the position of the posterior end, which is more elevated above the base-line, so that the lower margin of the shell is more strongly convex, its posterior part running more decidedly upwards. But this character is not observed in the creek-forms. Also the posterior "wing" is generally more distinct in *A. cataracta,* although often very low.

On the average the color of *A. cataracta* is brighter green than in *A. grandis.* It is light to dark green, rarely shading into brownish and blackish, often very brilliant, with concentric lighter and darker bands, and the dark green rays are also more distinct upon the disk; though there are specimens which do not show any rays. The broad rays of the posterior slope are often strongly developed and broadened, so as to render the whole posterior slope blackish green.

In this species as in its allies, the female sex is sometimes indicated by a swelling of the valves posteriorly to the middle, but not all females exhibit this character.

| | L. | H. | D. | |
|---|---|---|---|---|
| *Size:* 1. Flinton, Cat. No. 61.3637 (largest on hand) | 128 mm. | 72 mm. | 45 mm. | pond-form |
| 2. do. " " 61.3636 | 125 " | 65 " | 44 " | pond-form |
| 3. Lockhaven, Cat. No. 61.4173 (♀ gravid) | 112 " | 56 " | 42 " | pond-form |
| 4. Tioga, Cat. No. 61.4171 (♀ gravid) | 85 " | 46 " | 27 " | creek-form |
| 5. Avondale, Cat. No. 61.4167 | 86 " | 42 " | 31 " | creek-form |
| 6. York Haven, Cat. No. 61.4727 (♂) | 84 " | 47 " | 28 " | creek-form |
| 7. Schuylkill, Philadelphia, Cat. No. 61.816 | 87 " | 50 " | 33 " | *tryoni*-type |

These measurements do not express the maximum size, and considerably larger specimens are on record.

*Soft parts* practically identical with *A. grandis* (See Ortmann, 1912, p. 293). *Glochidia* figured by Lefevre & Curtis, 1910, p. 97, fig. C, and 1912, p. 146, fig. C.

*Breeding season:* Conner says (1907 and 1909) that this species is gravid from September to May, and that the interim falls in June, July, and August. I have collected gravid females on July 23, 1908; August 19, 1909; Aug. 21, 1908; Aug. 24, 1909; Sept. 5, 1909; March 19, 1911; April 24, 1909.

Of these dates, July 23 is surely an exceptional case (only one specimen was gravid among a large number). The dates in August mark the beginning of the

breeding season, and are earlier than Conner's records. Some of the specimens collected on April 24 were found discharging. This would establish the breeding season as lasting from August to May, a condition, which is much like that seen in *A. grandis.* It seems, that the glochidia are discharged rather early, for I never found any charged females in May.

*Remarks:* There still might be some lingering doubt, as to whether *A. cataracta* is specifically distinct from *A. grandis.* However, I have never seen any specimens, which might be called intergrades, and wherever I have examined the beak-sculpture, it has always been possible to distinguish these two species by this character. Nevertheless they are closely allied, and there is no question that *A. cataracta* is the eastern representative of the western *A. grandis.* The two forms are geographically well separated. It is true that in New York the ranges do overlap, but I think this is due to a secondary, postglacial expansion of the two species into the glacial area. During glacial times, they undoubtedly were completely separated (Ortmann, 1913, pp. 325, 363–365). Walker's opinion, expressed incidentally, that *cataracta* is closely allied to the European *A. cygnea,* and might be a co-immigrant with *Margaritana margaritifera* from Europe, cannot be maintained. Compare also Latchford (1914, p. 10).

A rather strong argument for the specific distinctness of *A. grandis* and *cataracta* is, as I believe, their different behavior or reaction to environment. Both possess a creek- and a pond-form, but while the reaction to the pond-environment in *A. grandis* is to develop a large, high and comparatively short shell (*A. grandis gigantea*), in *A. cataracta* a more elongated shell is the result, with a "rostrate" posterior end. This latter characteristic shape of the shell is never found distinctly in *A. grandis.* On the other hand, the creek-form of *A. grandis* is subovate, with the anterior end broad, and the posterior narrowed, while the creek-form of *A. cataracta* is rather subelliptical, with the anterior and posterior ends generally rather equally narrowed.

The short and high type of shell, so common in *A. grandis,* is much rarer in *A. cataracta,* but it is present. Lea's "species" *williamsi, virgulata,* and *tryoni* represent this. They may be described as follows.

*A. williamsi.* (*Type locality* Lower Potomac.) High and short, with better developed posterior wing, so that the upper and lower margins of the shell become subparallel. Sometimes the posterior wing may be so high that the posterior part of the shell appears higher than the anterior (ovate, with anterior end narrower).

*A. tryoni.* Closely resembling *A. williamsi,* but with the posterior wing not

so high, so that the shape becomes short-ovate, with the posterior end narrower.

*A. virgulata.* (*Type locality* North Carolina.) In shape intermediate between *A. williamsi* and *A. tryoni*, but with brighter coloration and more distinct rays. This is, according to Simpson (1914, p. 388) a southern form of *A. cataracta.*

Such short and high shells seem to be rather scarce in Pennsylvania, but the *tryoni*-type occurs in the larger rivers (Delaware and Schuylkill), and might be called characteristic of this environment.

The thickness of the shell is also variable in *A. cataracta;* the pond-forms being generally thinner, while the creek-forms are thicker. *A. cataracta* is also quite variable in the convexity of the valves; and there are more compressed and more inflated shells, both in ponds and creeks. The inflation, if present, is restricted to the disk, and does not extend to the umbos, and forms having inflated beaks, like *A. grandis footiana*, are not known among the variations of *A. cataracta*, except possibly in the South, among the *virgulata*-type, in which there seems to be a tendency in this direction.

The various forms of *A. cataracta*, described above, are all connected by intergrades, and they seem to be special reactions to special environmental conditions, although we are not in all cases sure what are the essential features of the environment, which are active. In the Schuylkill Canal I found, for instance, shells resembling the creek-form (but thin-shelled), where we should rather expect the pond-form. But here the bottom of the canal was somewhat stony, with very little mud, and it is quite possible, that in this case the character of the bottom was all important. Specimens from Echo Lake, Monroe Co., more closely resemble the creek-form. Since these various forms turn up all over the range of the species, they are to be regarded simply as variations, not as varieties. The idea, that they may be species is entirely excluded.

I should add here a few words about a peculiar, distorted form, received from Mr. C. H. Conner from the Delaware River, Newbold, Gloucester Co., New Jersey. There are five specimens, resembling in general characters the *tryoni*-type, but all possessing a peculiar radial rib, running from the beaks toward the lower margin of the shell, and in front of the rib the shell is somewhat compressed. It seems as if the growth of the shell in its anterior part had been checked or retarded. The specimens look decidedly like cripples, and I take them for such, yet it is remarkable that a number of specimens showing the same deformation should be found at the same locality.

*Localities in Pennsylvania represented in the Carnegie Museum:*

*Delaware-drainage:*

Delaware River, Penn's Manor, Bucks Co. (young, approaching *tryoni*).
White Clay Creek, Avondale, Chester Co. (typical creek-form).
Crum Creek, Delaware Co. (Hartman collection) (creek-form, but thin).
Schuylkill Canal, Manayunk, Philadelphia Co. (thin-shelled creek-form).
Schuylkill River, Philadelphia (Hartman collection) (labeled *tryoni*, and representing this type).
Wissahickon Creek, Roxboro, Philadelphia Co. (creek-form).
Little Neshaminy Creek, Grenoble, Bucks Co. (creek-form).
In a dry pond of Mahoning Creek, Lehighton, Carbon Co. (pond-form).
Echo Lake, Monroe Co. (G. H. Clapp, donor).

*Susquehanna-drainage:*[114]

Conewago Creek, York Haven, York Co. (creek-form).
Penn Canal, Selinsgrove, Snyder Co. (lake-form).
Chemung River, South Waverly, Bradford Co. (creek-form, remarkably light green, found in riffles).
Mill-race of Crooked Creek, Tioga, Tioga Co. (typical creek-form).
Ponds near paper-mill, Lockhaven, Clinton Co. (all typical pond-form).
Beaver Dam Creek, Flinton, Cambria Co. (D. A. Atkinson) (typical pond-form: from an old dam in the creek; some of the younger ones incline toward the creek-form).

*Potomac-drainage:*

Conococheague Creek, Greencastle, Franklin Co. (creek-form, unusually thick-shelled; from riffles in water heavily charged with lime); Scotland, Franklin Co. (creek-form, dwarfed).
Great Tonoloway Creek, Thompson Township, Fulton Co. (creek-form).

*Localities in Pennsylvania represented in the Philadelphia Academy of Natural Sciences:*

Eastwicks Park, Grays Ferry, Philadelphia (S. R. Roberts).
Wister Dam, Germantown, Philadelphia Co. (W. Stone).
Oxford Dam, Guinea Creek,[115] Woodbourne, Bucks Co. (H. W. Fowler).
Porters Lake, Pike Co. (S. N. Rhoads) (headwaters of Bushkill Creek, to Delaware).
Harvey Lake, Luzerne Co. (C. H. Conner) (W. Stone) (Harvey Creek, to North Branch Susquehanna).

*On New Jersey side of Delaware:*

Pond near Delaware River, Delanco, Burlington Co., New Jersey (H. A. Pilsbry).

*Other localities in the Carnegie Museum:*

Monmouth, Kennebec Co., Maine (Woods collection) (typical creek-form).
Charles River, Cambridge, Middlesex Co., Massachusetts (Mrs. L. D. Thompson) (creek-form).
Lake Ontario, Braddock Bay, Manitou Beach, Monroe Co., New York (R. H. Santens).[116]

[114] A dead and broken shell was seen, but not taken, in the Juniata River (Raystown Branch) at Ardenheim, Huntingdon Co.

[115] No such name is on the topographical map; the creek at Woodbourne is a branch of Mill Creek.

[116] One specimen, collected together with specimens of *A. grandis footiana*, mentioned above. It has the typical shape of the creek-form of *A. cataracta*, and differs from the others in the beaks, which are not inflated. Beak-sculpture poorly preserved, but apparently of the *cataracta*-type.

Backwater of Hudson River, Milton, Ulster Co., New York (H. H. Smith) (young, intergrading from pond-form to *tryoni*-type).

Binghamton, Broome Co., New York (H. H. Smith).[117]

Culvert Pond, Sussex Co., New Jersey (J. F. L. Raeschen) (creek-form, but thin-shelled).

Delaware-Raritan Canal, Aqueduct, near Princeton, Mercer Co., New Jersey (young, *tryoni*-type).

Delaware River, Fish House and North Cramer Hill, Camden Co., New Jersey (from both places the creek-form); Newbold, Gloucester Co., New Jersey (C. H. Conner) (cripples).

Potomac River, Washington, D. C. (Hartman collection) (*tryoni*-type).

South Branch Potomac River, Romney, Hampshire Co., West Virginia (chiefly creek-form, but some, from quiet pools, inclining to pond-form).

South River (upper Shenandoah), Waynesboro, Augusta Co., Virginia (thin-shelled creek-form from a quiet pool).

Paper-mill, Salem, Forsyth Co., North Carolina (Holland collection) (*virgulata*-type).

Ashburn Creek, Mecklenburg Co., North Carolina (Hartman collection) (*virgulata*-type).

*Distribution and Ecology in Pennsylvania* (See fig. 15): In Pennsylvania this species belongs to the Atlantic-drainage. It has indeed been reported by Marshall

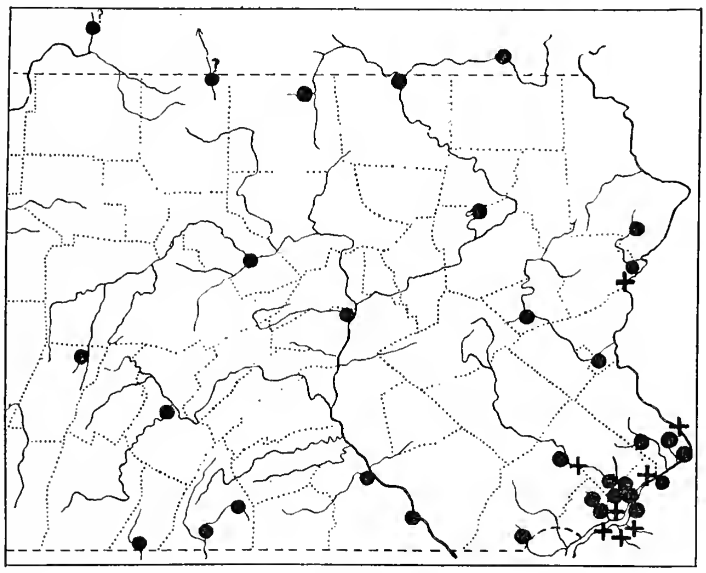

FIG. 15.

● *Anodonta cataracta*. + *Anodonta implicata*.

(1895) from the headwaters of the Genesee River in Potter Co., but this requires confirmation. When I collected in the Genesee River and Cryder Creek, at Genesee, Pennsylvania, I did not find any *Anodontas*.

As the records show, *A. cataracta* is found in the drainages of all three Atlantic rivers, the Delaware, Susquehanna, and Potomac. It apparently is most abundant in the lowlands and on the Piedmont Plateau, but goes up considerably towards

[117] The label says: "Chemung River," but Binghamton is not on this River; the specimen has all the earmarks of a pond-shell.

and into the mountains, farthest in the Susquehanna, where it ascends to Cambria Co., west of the Allegheny Front. Here it is closest to the divide, and it is interesting to note, that on the other side in the Ohio-drainage of Indiana and Westmoreland Counties, the creek- and pond-forms of *A. grandis* turn up.

I collected the pond-form in rather small (artificial) ponds, with very muddy bottoms, and also, but more rarely, in quiet pools in creeks. I obtained the creek-form most commonly, but it is rather erratic in distribution. It seems to avoid the larger rivers (although found under special conditions in the estuary of the Delaware). It favors smaller rivers (Chemung) and creeks. Here it lives on gravelly bottoms, in more or less strongly flowing water (even in riffles), or in more quiet pools in gravel, sand, or mud. The short and high form (*tryoni*-type) seems to prefer large rivers with muddy bottoms, but I have not observed it often enough to express a final opinion.

Probably this species has a more general distribution in eastern Pennsylvania, and the pond-form might especially be found in many other ponds (and lakes): these localities, however, are often not easily accessible, and it is hard to locate this shell in them.

*General distribution: Type locality,* not given by Say, but probably is eastern Pennsylvania.

Simpson (1900) reports this species from "Lower St. Lawrence-drainage; streams draining into the Atlantic south to North Carolina."

In the St. Lawrence-drainage, it has been reported from Lake Ontario (Hamilton Bay, Marshall, 1895, and Toronto, Latchford, 1914), and this is confirmed by a specimen in the Carnegie Museum. Farther down it is known from various points along the St. Lawrence, and also from the Lake Ontario-drainage in western New York. But there is some doubt whether all the records given by Marshall (1895) from this section actually refer to this species. At any rate two of these records: Buffalo Creek in Erie Co. (to Lake Erie), and Ischua Creek, Cattaraugus Co. (to Allegheny River) appear to me very doubtful, and should be confirmed. In this region, indeed, it seems, that the ranges of *A. grandis* and *A. cataracta* overlap, and on account of the great resemblance of these two species, it is quite possible, that some of the identifications are not correct. This question deserves special study.

On the Atlantic side this species goes northward to Maine, as is shown by one of our localities, and it has been reported by Jackson (1908) North Haven Island, Knox Co. and Lermond (1909) Cumberland Co. Walker & Coolidge (1908) give it from Keene, Cheshire Co., New Hampshire, Adams (1842) from

Middlebury, Addison Co., Vermont, and Marshall (1895) from Benson, Rutland Co., Vermont. It is also present in Rhode Island (Carpenter, 1890), and is frequent in the western and central parts of Massachusetts (Gould-Binney, 1870). Thence southward it becomes rather common, but south of Pennsylvania records become scarce. No positive localities are at hand from Maryland. From Delaware it has been mentioned by Rhoads (1904), and the localities from Virginia and North Carolina are few. I have found it in the Potomac-drainage in West Virginia and Virginia. According to Simpson it goes only to North Carolina, but there are old records given by Lea for his *virgulata* and *williamsi* from Georgia, so that the southern boundary of this species becomes obscure; in addition a number of closely allied forms or species have been described from the southern states, the standing of which remains to be investigated.

We must regard *A. cataracta* as a form characteristic of the northern section of the Atlantic Coastal Plain and the Piedmont Plateau, from which center it has spread more or less toward the Allegheny Mountains, but without crossing the divide; and from which it has widely spread, probably in Postglacial times, to the northeast and north, and also slightly northwestwards, reaching New England and the lower St. Lawrence basin, where it has met the eastward expansion of the western *A. grandis* (See Ortmann, 1913*a*).

### ANODONTA IMPLICATA Say (1829).

*Anodonta implicata* SAY, SIMPSON, 1914, p. 391.

Plate XI, figs. 2, 3.

*Records from Pennsylvania:*

Lea, 1838 (Schuylkill River, Philadelphia) (as *A. newtonensis*).
Gabb, 1861 (League Island, Philadelphia).
Hartman & Michener, 1874 (Schuylkill River, Chester Co.).
Marshall, 1895 (Philadelphia).
Ortmann, 1909*b*, p. 206.

*Characters of the shell:* Large, elongated, similar in shape to the pond-form of *A. cataracta*, but with the posterior end not so elevated; rather thick-shelled, and noticeably thickened along the lower anterior margin (from the middle forwards). Nacre more or less reddish, or salmon-color.

It is also said that the shell is more inflated (subcylindrical) than in *A. cataracta*, and that the color of the epidermis is lighter (yellowish) and has no rays. This, however, probably is not always the case. Marshall (1890) says, that the beak-sculpture is also different, with the sinus less developed, being gentle in the

earlier, and missing in the later bars. This holds good in at least one of the specimens before me. The rough epidermis is also given as a character, as distinguished from the shining *cataracta*, but this is not confirmed by my material.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Yardley, Cat. No. 61.3639 | 75 mm. | 41 mm. | 26 mm. |
| 2. do. " " do. | 74 " | 40.5 " | 25 " |

These are the only specimens of considerable size collected by myself, and they are hardly more than half the maximum size attained by this form.

*Soft parts* and *glochidia* unknown.

*Breeding-season:* According to Conner (1909) from September to May (like *cataracta*). Lefevre & Curtis (1912, p. 141) enumerate this species under the forms with long breeding-season.

*Remarks:* This is a form the taxonomic standing of which is as yet obscure and I myself have not been able to form a clear conception of it. According to previous authors, the characters given above are essential, but they apply only to the adult shell, and I am unable to say much about the young shell. The smallest shells I have seen are those I collected in the Delaware at Shawnee (Length: 58, 46, 41, and 39 mm.). Of these the largest shows traces of the thickening at the lower anterior margin, while the smaller ones do not. These shells have the epidermis rather yellowish, and the nacre has a good deal of salmon-color, and therefore I think they actually represent this species. All other shells I have seen are larger, and show the character of the thickening of the margins well-developed. The best account of this shell has been given by Gould (Binney, 1870, p. 180), but even here it is admitted that the young shells are difficult to distinguish from *A. fluviatilis* (= *cataracta*).

The Carnegie Museum possesses only eight specimens, to which I should apply the name *implicata*. One (without locality) is from the Hartman collection, and is certainly this form. It is large (L. 122 mm.), elongate (H. 67), and swollen (D. 56). Its epidermis is shining (not rough) and of a yellowish-olive to light brown color, without any rays. The beak-sculpture is as described by Marshall. The valves also show the characteristic thickening along the anterior lower margin, and the nacre is pale pinkish. Another specimen was sent to me by C. H. Conner (Timber Creek, Gloucester, New Jersey, just south of Newton Creek, Camden Co., the type locality of Lea's *newtonensis*). It is 103 mm. long, 49 high, and 41 in diameter. Thus it is rather elongated, swollen, and subcylindrical. The epidermis is blackish brown (not pure black as in the figure of *newtonensis*), the beaks are eroded, and the beak-sculpture gone. The thickening of the margin is present, and the nacre is pinkish or salmon.

In addition, I have collected two specimens in the Delaware River in Bucks Co., which are the specimens of which the measurements are given above, and to them must be added the four young ones, mentioned above, taken at Shawnee, Monroe Co. All these are much smaller, and are not at all swollen nor subcylindrical. The color of the epidermis is greenish with light brown or yellowish concentric bands, without distinct rays, or else nearly uniformly light brown, darker behind. The larger ones show the thickening of the shell, and all have a more or less distinct tint of salmon in the nacre.

In the collections of the Philadelphia Academy of Natural Sciences I have seen comparatively few specimens, hardly more than a dozen. The thickening of the margin of the shell is always present, often also the pinkish color of the nacre and the inflation of the valves. The color of the epidermis ranges from greenish yellow to blackish.

*Localities represented in the Carnegie Museum:*

Delaware River, Yardley, Bucks Co.; Shawnee, Monroe Co., Pennsylvania.
Timber Creek, Newbold, Gloucester Co., New Jersey (C. H. Conner).

*Localities represented in the Philadelphia Academy:*

Schuylkill River (I. Lea).
Thorps Mill-Pond, Branchton, Philadelphia (S. R. Roberts).
Delaware River, Torresdale, Philadelphia Co., Pennsylvania (S. R. Jacob).
Channel of Delaware River, about 600 feet off New Jersey shore, in 35–45 feet depth, muddy bottom, " East of North end of Little Tinicum Island " (L. Woolman).[118]

*Distribution and Ecology* (See fig. 15): *Type locality,* Pond, Danvers, Essex Co., Massachusetts (Say).

Simpson (1900) gives the range of this species as: "St. Lawrence-drainage; north to Lake Winnipeg; south in streams flowing into the Atlantic to Virginia." I am unable to substantiate this, and the localities on record only in part confirm Simpson's statement. The question also arises, whether all the citations recorded actually refer to this species. At all events, I seriously question the record "Lake Erie, Port Dover, Canada" (Marshall, 1895). South of New Jersey and Pennsylvania I know of no reliable records whatever.

In Pennsylvania this species has only been found in the neighborhood of Philadelphia, in the Schuylkill and Delaware Rivers, and in ponds. It occurs also on the opposite side of the Delaware in New Jersey. My own localities are farther up the Delaware. Not a single specimen has ever turned up in the Susquehanna

[118] Little Tinicum Island has no north end; probably what is meant is " south of east end." The locality is off Billingsport, Gloucester Co., New Jersey.

and Potomac drainages. Altogether it seems to me, that this form is more northern in its distribution, and the majority of localities are from New York, Connecticut, and Massachusetts, in which direction it goes as far as Maine (Lermond, 1909). Generally it is reported as living in ponds, but sometimes also in rivers. The locality in the deep channel of the Delaware (35 to 45 feet depth), given above, is quite interesting and possibly suggestive. Further studies on this species are very desirable. (See Ortmann, 1913*a*, p. 363.)

### Anodonta ohiensis Rafinesque (1820).

*Anodonta imbecillis* Say. Simpson, 1914, p. 395; *Lastena ohiensis* (Rafinesque) Utterback, 1916, p. 109.[119]

Plate XI, fig. 4.

*Records from Pennsylvania:*

Ortmann, 1909*b*, p. 195 and 202.

*Characters of the shell:* Shell small, at the utmost of medium size, very thin. Outline subelliptical, rather elongate, rounded anteriorly, narrowed and somewhat pointed behind. Lower margin gently convex, less so in the posterior part, sometimes almost straight in the middle. Upper margin straight, forming a more or less distinct angle with the obliquely descending posterior margin, and in general this angle is elevated to form a wing, which is rarely entirely obliterated. Beaks depressed, and not at all elevated above the hinge-line. In young shells the beaks slope down obliquely (roof-like) from the hinge-line; in older, more swollen shells, they are nearly or entirely horizontal. Beaks placed anterior to the middle of the shell. Beak-sculpture fine, weak, and irregular, consisting of four to six subconcentric ridges, of which the later ones have a faint sinuation, which is only wavy, and does not form an angle. Often this sinus is represented only by an interruption of the bar.

Shell of young specimens very slightly swollen, or even compressed; in older ones it becomes more inflated, and assumes in extreme cases an almost subcylindrical shape. Posterior ridge very indistinct, rounded; greatest diameter of the shell about in the middle. Posterior slope more or less compressed and elevated into the wing of the upper posterior angle.

Epidermis lighter or darker green, often beautifully grass-green, grayish, brownish, or yellowish near the beaks, with concentric, darker growth-rests, and

[119] I object to the use of the generic name *Lastena* for this species. It is not the type of Rafinesque's subgenus *Lastena*, and a type for this genus was not designated until Simpson (1900, p. 654), selected *lata* Rafinesque for it. It might possibly be desirable to generically separate this species from the other species treated in this paper under *Anodonta*, but in this case, a new name should be found.

with dark green, more or less distinct, rays on the whole disk. Two or three dark green to blackish rays generally well developed upon the posterior slope.

Hinge edentulous, forming a straight line, or with a faint indication of a wave under the beaks. Beak-cavity shallow. Dorsal muscle-scars in the beak-cavity. Adductor muscle-scars indistinct. Nacre blueish white, silvery, iridescent, sometimes slightly cream-color toward the beak-cavities.

This species being a hermaphrodite does not show any sexual differences in the shell.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Erie, Cat. No. 61.3291 | 83 mm. | 41 mm. | 28 mm. |
| 2. Waterford, Cat. No. 61.4178 | 67 " | 32 " | 24 " |
| 3. do. " " do. | 56 " | 27 " | 16 " |
| 4. Edinboro, Cat. No. 61.3290 | 48 " | 25 " | 12 " |

The largest specimen represents about the maximum size attained by this species. Generally it remains considerably smaller (Length between 50 and 60 mm.).

*Soft parts* (See Ortmann, 1912, p. 291). *Glochidia* figured by Lea (Obs. VI, 1858, Pl. 5, fig. 36); Ortmann (1911, Pl. 89, fig. 13); Surber (1912, Pl. 1, fig. 2). Surber's measurements are: $0.31 \times 0.29$ (longer than high), while I gave: $0.30 \times 0.31$ mm. (higher than long).

*Breeding-season:* My dates for gravid females are: June 2, 1908 (eggs); July 12, 1910 (discharging); Sept. 14, 1909 (eggs and glochidia); May 21, 1908 (glochidia and discharging); May 22, 1909 (glochidia and discharging); May 24, 1909. Surber (1912, p. 7) gives March, June, July, August, and September as months when gravid individuals are present. From Arkansas I have gravid specimens collected by Wheeler on February 20, 1913; June 14, 1911; July 17, 1911; and in November, 1911.

This is undoubtedly a *bradytictic* form, and according to the above dates, it apparently breeds "all the year round," *i.e.*, the succeeding breeding seasons overlap in June and July, but probably not in the same individual.

*Remarks:* A well-marked species, which is easily recognized by its shape and color. As far as my material permits a conclusion, it varies very little, and the variations are restricted to the proportional length of the shell and its degree of obesity; the latter of which in part depends on age. The color of the epidermis is also somewhat variable, being lighter or darker green, but specimens from the same locality are generally very uniform.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Lake Erie, Presque Isle Bay, Horseshoe Pond, and beach-pools on Presque Isle, Erie, Erie Co.
Leboeuf Creek (outlet of lake), Waterford, Erie Co.

Conneauttee Lake, Edinboro, Erie Co.

*Other localities represented in the Carnegie Museum:*

*Lake-drainage:*

Lake Erie, La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).
Miami and Erie Canal, Lucas Co., Ohio (C. Goodrich).

*Ohio-drainage:*

Tuscarawas River, Ohio (Holland collection).
Scioto River, Columbus, Franklin Co., Ohio (H. H. Smith).
Wabash River, Bluffton, Wells Co., Indiana (C. Goodrich).

*Tennessee-drainage:*

Paint Rock River, Paint Rock and Princeton, Jackson Co., Alabama (H. H. Smith).

*West of Mississippi:*

James River, Galena, Stone Co., Missouri (A. A. Hinkley).
Lawrence, Douglas Co., Kansas (R. L. Moodie).
Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).
Big Deceiper Creek, Gum Springs, Clark Co., Arkansas (H. E. Wheeler).
Black Bayou, Victoria Co., Texas (D. A. Atkinson).

*Alabama-drainage:*

Black Warrior River, Lock 11, Tuscaloosa, Tuscaloosa Co., Alabama (H. H. Smith).
Pond at Holt, Tuscaloosa Co., Alabama (H. H. Smith).
Beaver Creek and Canoe Creek, St. Clair Co., Alabama (H. H. Smith) (Coosa-drainage).
Othkalooga Creek, Calhoun, Gordon Co., Georgia (H. H. Smith) (Coosa-drainage).

*Atlantic-drainage:*

Greenfired Mill, Wilmington, New Hanover Co., North Carolina (G. H. Clapp donor).

*Distribution and Ecology in Pennsylvania* (See fig. 14): This species is restricted to the northwestern section of our state (Erie Co.), and is principally found in Lake Erie, where it inhabits the sandy shores of Presque Isle Bay and the beach-pools at the eastern end of Presque Isle. At two places I discovered it in the Ohio-drainage, in the headwaters of French Creek, in Conneauttee Lake, in the black muck of this lake; in the other case, at the outlet of Leboeuf Lake, on partly muddy bottom, in slack water, and partly on gravelly bottom and on shell marl in more strongly flowing water.

Baker (1898*a*) records it from muddy bottoms in creeks, small rivers, and ponds, and Scammon (1906) calls it a lover of quiet water and muddy or somewhat sandy banks. This agrees well with my observations.

The peculiar distribution in Pennsylvania resembles somewhat that of certain other species, which are found only in the northwestern part of our state.

*General distribution: Type locality,* Ohio River (Rafinesque).

Simpson (1900) says: "Entire Mississippi-drainage area; southern Michigan; North Carolina to Georgia; southwest to Matamoras, Mexico." This indicates a

very wide range, but it should be qualified somewhat. It is actually found over large parts of the Mississippi-drainage, but records are missing from the tributaries South of the Ohio. In the Cumberland-drainage, it is only found in ponds near Clarksville, Montgomery Co., Tennessee (Wilson & Clark, 1914); and in the Tennessee-drainage it goes up to northern Alabama, but seems to be missing in East Tennessee. Northward it passes into the lake-drainage in Wisconsin (Milwaukee, Lapham, 1860), Illinois (Baker, 1906), Michigan (Walker, 1898), Ohio (Sterki, 1907*a*; Walker, 1913), and advances northeastwards to northwestern Pennsylvania and western New York, reaching, by way of the Erie Canal, Herkimer Co., New York (Lewis, 1860; Marshall, 1895). In the upper Mississippi, it ascends to southeastern Minnesota (Grant, 1886; Holzinger, 1888).

Westward it occurs in the tributaries of the Mississippi in Kansas (Scammon, 1906), Arkansas, Oklahoma, and northwestern Louisiana (Vaughan, 1893; Frierson, 1899). It is frequent in the streams flowing into the Gulf in Texas (Singley, 1893), reaching Matamoras in Mexico, according to Simpson. In addition it is known from the Alabama-drainage, going thence into Georgia and the Carolinas. This section of the range is represented in the Carnegie Museum by specimens from Alabama, Georgia, and North Carolina, and is probably connected westward with the localities in Louisiana.

### Genus Anodontoides Simpson (1898).

Ortmann, 1912, p. 293; Simpson, 1914, p. 466.

Type *Anodonta ferussaciana* Lea.

Only one species is known, which, however, has several varieties, one of which is found in Pennsylvania.

Key to the Forms of Anodontoides.

$a_1$. Shell compressed, and less elongated.......... *A. ferussacianus.*

$a_2$. Shell more swollen, more elongated, thus approaching the subcylindrical shape. *A. ferussacianus buchanensis.*

### Anodontoides ferussacianus (Lea) (1834).

*Anodontoides ferussacianus* (Lea) Simpson, 1914, p. 467.

Plate XI, fig. 5.

*Records from Pennsylvania:*

Ortmann, 1909*b*, p. 195.

*Characters of the shell:* Shell small to medium in size, thin. Outline subelliptical or subovate, moderately elongate, rounded anteriorly as well as posteriorly,

more rarely somewhat narrowed behind. Lower margin gently and rather regularly curved, often nearly straight in the middle. Upper margin gently curved, and curved down into the posterior margin, forming, or not forming a slight angle, without a distinct wing. Beaks convex, but not much swollen, only slightly elevated above the hinge-line, placed more or less anterior to the middle. Beak-sculpture consisting of three to four subconcentric, fine, and rather sharp ridges, the first two or three placed obliquely to the direction of the hinge-line (bent up behind), the following ones showing a more or less distinct angle. On the posterior slope there are several fine radiating lines, indicating additional bars, obliterated on the disk. Double-looped structure of the bars is entirely absent (See beak-sculpture of var. *buchanensis*, as figured by Marshall, 1890, figs. 13, 14).

Shell more or less compressed to moderately swollen, greatest convexity upon the posterior ridge, which is rounded and not sharply marked. Posterior slope slightly compressed.

Epidermis light green to olive, grayish, brownish or blackish, generally grayish, yellowish, or light brown towards the beaks, mostly with numerous narrower or wider, dark green rays, which, however, are often indistinct, and disappear in old shells on account of the general darkening of the epidermis. Upon the posterior slope, there may, or may not, be a few darker, broader rays. In addition, the epidermis is often concentrically banded, the growth rests being marked by blackish color.

Hinge practically edentulous, straight or slightly downward curved anteriorly. In front of the beaks it is more or less (often very indistinctly) incurved, and here shows rudiments of cardinals in the shape of small tubercles, swellings, or mere irregularities. Beak-cavity shallow. Dorsal muscle-scars faint, in front part of beak-cavity. Adductor muscle-scars faint.

Nacre bluish white, sometimes discolored by greenish or creamy tints toward the beak-cavity; more or less iridescent, chiefly towards the posterior end.

Shell of male and female hardly different. Although Baker (1898*a*, p. 73) says that the shell of the female is more inflated posteriorly (*i.e.*, at and in front of posterior ridge) this inflation is not always present. If it is distinctly developed, we may safely assume that we have to deal with a female, but many females do not possess it.

| | | L. | H. | D. |
|---|---|---|---|---|
| *Size:* | 1. Greenville, Cat. No. 61.3294 | 73 mm. | 38 mm. | 28 mm. |
| | 2. do. " " do. | 68 " | 38 " | 19 " |
| | 3. Shenango, Cat. No. 61.4207 (♀) | 71 " | 38 " | 25 " |
| | 4. do. " " do. | 62 " | 35 " | 18 " |

This species grows somewhat larger in some western streams.

*Soft parts* (See Ortmann, 1912, p. 294). *Glochidia* figured by Lea (Obs. VI, 1858, Pl. 5, fig. 35) (immature), and Ortmann (1911*b*, Pl. 89, fig. 12).

*Breeding-season:* Records for gravid females are at hand for: August 7, 1908; Aug. 8, 1908; Aug. 26, 1911; Sept. 13, 1917; Sept. 27, 1909; Oct. 10, 1907; and May, 1908. *Glochidia* have been found in September, October, and May; and on May 14 discharging specimens have been seen.

Thus this species is bradytictic. The breeding season begins in August and lasts till May.

*Remarks:* This is a species, which has a rather indifferent, generally subelliptical shape, without any striking features. Externally it looks like a small *Anodonta*, and the thickness of the shell is also much like that of *Anodonta*. Moreover the shape of the shell is rather variable, being sometimes longer, or shorter, and more or less compressed. If the beaks are well-preserved, there is no mistake about its identity, since the beak-sculpture is quite peculiar and characteristic. Eroded shells may be distinguished from *Anodonta* by the hinge-line, which is not so straight.

In general shape *Strophitus edentulus* is often much like this species, and, when the beaks are eroded, the two species are sometimes hard to tell apart. But they may be distinguished by the thinner shell of *Anodontoides*, the interior of which is blueish white and strongly iridescent, while in *Strophitus*, especially in older specimens, the nacre is more thickened toward the beak-cavity, and there turns pure white, creamy, or even salmon-color, and is not so iridescent. Further in *Strophitus* the rudiments of the cardinal teeth are more distinct, and the hinge is more incurved in front of the beaks. When the beaks are preserved, *Strophitus* is distinguished by the heavier beak-sculpture. Of course, the soft parts, chiefly those of the female, when it is gravid, are entirely different in these two species.

The convexity of the valves varies greatly in *Anodontoides ferussacianus*, and becomes sometimes rather great, thus approaching the shape of the var. *buchanensis* (see below). Such specimens turn up now and then among normal ones, and at a few localities more frequently, as for instance, in Conneaut Lake. Some shells from this locality (and also from the outlet of the lake) might safely be called *buchanensis;* while others, found with them, have the normal, more compressed shape; similar conditions prevail in the uppermost Shenango River, at Linesville. We actually have here the intergrades between the normal form and the variety.

It should be noted, that the form from Conneaut Creek (tributary to Lake Erie) is the normal form, not the Lake Erie form (*buchanensis*).

*Localities in Pennsylvania represented in the Carnegie Museum:*

Shenango River, Sharpsville, Shenango, and Jamestown, Mercer Co.; Linesville, Crawford Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Little Shenango River, Greenville, Mercer Co.; Hadley, Mercer Co. (D. A. Atkinson).
Randolph Run, Hartstown, Crawford Co.
Conneaut Lake and Conneaut Outlet, Crawford Co.
Cussewago Creek, Mosiertown, Crawford Co. (H. & L. Ellsworth).
French Creek, Meadville, Crawford Co.
Conneaut Creek, West Springfield, Erie Co.

*Other localities represented in the Carnegie Museum:*

*Lake-drainage:*

Tributary of Lake Ontario, Cobourg, Northumberland Co., Ontario, Canada (D. Stewart).
St. Lawrence River, Clayton, Jefferson Co., New York (Miss A. H. Robinson).[120]
Genesee River, Rochester, Monroe Co., New York (R. H. Santens).
Swan Creek, Toledo, Lucas Co., Ohio (C. Goodrich).
Cedar Creek, Jerusalem Township, Lucas Co., Ohio (C. Goodrich).
Ten Mile Creek, Silica, Lucas Co., Ohio (C. Goodrich).
Silver Creek, Williams Co., Ohio (C. Goodrich).
Otter Creek, Monroe Co., Michigan (C. Goodrich).
Raisin River, Tecumseh, Lenawee Co., Michigan (C. Goodrich).

*Ohio-Mississippi-drainage:*

Tuscarawas River, Ohio (Holland collection).
Winona Lake, Kosciusko Co., Indiana (E. B. Williamson).
Kishwaukee River, Rockford, Winnebago Co., Illinois (P. E. Nordgren).
Pocatalico River, Raymond City, Putnam Co., West Virginia.
Fleming Creek, Pleasant Valley, Nicholas Co., Kentucky.
Cumberland River, Orby, Bell Co., Kentucky.

*Western:*

Hinkston Creek, Columbia, Boone Co., Missouri (D. K. Greger).
Smoky Hill River, Logan Co., Kansas (C. W. Gilmore).
Lodgepole Creek, Julesburg, Sedgwick Co., Colorado (G. H. Clapp, donor).
Big Thompson Creek, Loveland, Larimer Co., Colorado (A. Koenig).

*Distribution and Ecology in Pennsylvania* (See fig. 16): This species is found exclusively in the northwestern section of our territory, mainly in the headwaters of the Beaver system, and of French Creek. In addition it occurs in Conneaut Creek, a tributary of Lake Erie. Thus it obviously falls into the same category as some other species before mentioned. Apparently its metropolis in our state is the upper Shenango, where it is abundant, for instance at Linesville and in Pymatuning Creek. It has never been found below Sharpsville, just below the mouth of Pymatuning Creek. In French Creek proper it is rare (only one found at

[120] Dwarf, pale race, possibly the var. *modestus* (Lea).

Meadville), while it is rather frequent in Conneaut Outlet and in the lake itself. This peculiar feature will be discussed elsewhere. It suffices to mention here that

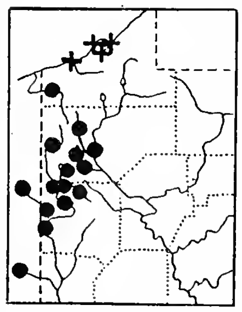

FIG. 16.

● *Anodontoides ferrussacianus.*
+ *Do. feruss. buchanensis.*

all these systems (Beaver, Conneaut, French Creek) have been either naturally or artificially closely connected in the past.

Wherever I found this species in abundance it preferred comparatively quiet parts of the creeks, with little or no current, and with sandy-gravelly bottoms, with some admixture of mud. It also occurs in lakes, as for instance Conneaut Lake, and exhibits here the tendency to become more inflated, approaching thus the var. *buchanensis.* In Conneaut Lake it is found chiefly on sandy bottom at the south end of the lake, but also elsewhere in gravel. It seems to be averse to larger streams with strong currents and rough bottoms.

Baker (1898*a*) says that it is a species frequenting muddy bottoms.

*General distribution: Type locality,* Ohio River, Cincinnati, Ohio (Lea).

According to Simpson this species is found generally in the Mississippi-drainage area; in the St. Lawrence system; the Red River of the North; the Saskatchewan River; and doubtfully in Connecticut (according to Linsley, 1845, at Whitneyville, New Haven Co.).

In the east its range certainly extends into New York state, as far as the Hudson River and the headwaters of the Susquehanna and Delaware systems (Marshall, 1895),[121] and it is frequent in the St. Lawrence-drainage in a form which is typical (see our specimens from the Genesee River). I have it also in rather typical development from a tributary on the Canadian side of Lake Ontario, and it has been reported from Montreal and Ottawa. Farther west, its northern boundary is uncertain, but it surely advances rather far northward, as is shown by the localities given by Walker (1898) for Michigan (Charlevoix, upper Penin-

[121] But it is not found in Pennsylvania in these rivers.

sula), by localities in Wisconsin and Minnesota, and the Canadian range given by Simpson. Southward it is well distributed over the states of Ohio to the Ohio River (Sterki, 1907*a*), Indiana (Call, 1896*a* and 1900), and Illinois (Baker, 1906; Forbes & Richardson, 1913). It has not been found in the Ohio above Cincinnati, and south of the Ohio. It does not occur in southwestern Pennsylvania and in the headwaters of the Monongahela and in the Little Kanawha in West Virginia. But it turns up in the Big Kanawha-drainage, and is found in the Licking system in Kentucky. It is known from the Cumberland (Wilson & Clark, 1914) (also Carnegie Museum), and is very rare in the uppermost Tennessee system (Powell River). (This will be discussed elsewhere.)

Westward *A. ferussacianus* goes across the Mississippi, where it is found in South Dakota, Iowa, and Kansas, advancing here, in the Kansas River-drainage, farther westward than any other shell (Decatur Co., Scammon, 1906, and Logan Co., Carnegie Museum). In addition, the Carnegie Museum has received material representing this species from the state of Colorado (Platte River-drainage), which extends its western range here to the foot of the Rocky Mountains.

Farther south this species has not been reported, and in general the range is rather northern.

### Anodontoides ferussacianus buchanensis (Lea) (1838).

*Anodontoides ferussacianus subcylindraceus* (Lea) Simpson, 1900, p. 660; *Anodontoides ferussacianus buchanensis* (Lea) Simpson, 1914, p. 469.

Plate XI, fig. 6.

*Records from Pennsylvania:*
Ortmann, 1909*b*, p. 202.[122]

*Characters of variety:* This form differs from the typical *ferussacianus* by the more convex valves and the more elongated outline, which renders the whole shell more nearly subcylindrical.

| | | | L. | H. | D. |
|---|---|---|---|---|---|
| *Size:* 1. | Presque Isle, | Cat. No. 61.1577 | 82 mm. | 39 mm. | 33 mm. |
| 2. | do. | Cat. No. 61.3295 | 81 " | 38 " | 28 " |
| 3. | do. | " " do. | 75 " | 38 " | 29 " |
| 4. | do. | " " do. | 66 " | 31 " | 26 " |
| 5. | do. | " " do. | 65 " | 31 " | 24 " |

*Soft parts* not different from those of the typical form. *Glochidia* not observed by myself. Surber (1912, Pl. 3, fig. 43) figures them; his measurements are:

[122] Pilsbry (1894, p. 30) records " *Anodonta subcylindrica* Lea " (sic!) from York Furnace, York Co. The specimens thus labeled in the Philadelphia Academy are *Anodonta cataracta* Say. (See above.)

$0.33 \times 0.33$, while my measurements for the typical form (1912, p. 294) are: $0.32 \times 0.32$ mm.

*Breeding season:* Not observed. According to Surber gravid specimens have been found in September and October.

*Remarks:* The subcylindrical, more elongated shape of the shell is the only reliable character by which this form may be recognized; and even this is not always equally well-developed. Lake Erie specimens may incline toward the normal form, and, on the other hand, more swollen individuals may turn up in the Ohio-drainage, chiefly in the lake environment.

Special attention should be directed to the fact that in Conneaut Creek, tributary to Lake Erie, the typical form is found; and parallel to this is the fact that likewise from tributaries of the lake in northwestern Ohio and southeastern Michigan this form is at hand.

In Lake Erie, principally in the beach-pools and ponds of Presque Isle, the var. *buchanensis* is also characterized by its color. The latter is not greenish, but is reddish brown, generally beautifully reddish chestnut near the beaks, shading to dull dark brown and blackish upon the disk and toward the margins. In most cases rays are very obscure or entirely absent, with the exception of a few indistinct blackish ones upon the posterior slope. This color, however, certainly is only a local, environmental effect. It resembles much the color observed in the beach-pool form of *Anodonta grandis footiana*, but is more intense, and, moreover, not all specimens from Presque Isle have it. From the bay I have specimens, which are distinctly green, with distinct rays, and hardly any rusty brown. Such specimens agree very closely with specimens from Conneaut Lake, and the connection of the variety with the type is thus complete.

*Localities represented in the Carnegie Museum:*

Lake Erie, Presque Isle Bay, and beach pools of Presque Isle, Erie, Erie Co., Pennsylvania.
Pond at mouth of Elk Creek, Miles Grove (North Girard), Erie Co., Pennsylvania.
Lake Erie, Port Dover, Norfolk Co., Ontario, Canada (C. Goodrich).
Lake Erie, Buffalo, Erie Co., New York (Hartman collection).
Raisin River, Adrian, Lenawee Co., Michigan (C. Goodrich).
Lake Huron, Port Huron, St. Clair Co., Michigan (N. M. Grier).
Bessey Creek, Cheboygan Co., Michigan (H. B. Baker).
Scioto River, Kenton, Hardin Co., Ohio (C. Goodrich).

*Distribution and Ecology* (See fig. 16): *Type locality*, Buck Creek, Ohio (Lea).[123]

In Pennsylvania this form is restricted to Lake Erie, and is found there in great numbers, chiefly in certain beach-pools on Presque Isle. It lives there in

[123] Location unknown. Possibly near Cincinnati?

the characteristic fine sand of the peninsula, sometimes mixed with more or less mud.

This variety has been reported from other localities in Lake Erie, for instance at Buffalo (Marshall, 1895), and also from Lake Michigan in Michigan (Walker, 1898) and Illinois (Baker, 1898*a*; Walker, 1913, p. 22). Records from other larger or smaller lakes and from canals are abundant from eastern Canada, Lower St. Lawrence region (according to Bell, 1859), New York (crossing over by way of Erie Canal to the Hudson at Albany) (Marshall, 1895), northern Ohio (Sterki, 1907*a*), Michigan (Walker, and Baker, 1914), as far north as Schoolcraft and Alger Cos., near Lake Superior (Winslow, 1917). But it also has been reported from creeks and rivers, and its type-locality is a creek in Ohio. It is found in New York, Ohio, Indiana (Call, 1896*a*, and 1900), and in Illinois (Baker, 1898*a*, and 1906) in streams running to the lakes as well as to the Ohio. But on the whole its range is more northeastern, and centers mainly in the drainage of the Great Lakes and the St. Lawrence. Southward and westward it does not go beyond Ohio and Indiana, nor beyond the northeastern corner of Illinois.

### Genus Alasmidonta Say (1818).

Ortmann, 1912, p. 294; Simpson, 1914, p. 492; Ortmann, 1914, p. 44.

Type *Monodonta undulata* Say.

This genus has been divided into subgenera by Simpson, but they have been somewhat modified by the present writer. Three subgenera are found in Pennsylvania.

#### Key to the Subgenera.

$a_1$. Hinge complete, with pseudocardinals and laterals, but the latter reversed, two in right, one in left valve. Beak-sculpture moderately heavy........................Subgenus *Prolasmidonta*.

$a_2$. Hinge incomplete, laterals obliterated, pseudocardinals present. Beak-sculpture very heavy.

- $b_1$. Pseudocardinals well-developed, stumpy. Posterior ridge weak, posterior slope smooth (rarely with traces of wrinkles). Rays not broken up into spots............Subgenus *Alasmidonta*.
- $b_2$. Pseudocardinals weak, compressed. Posterior ridge distinct, posterior slope more or less corrugated. Rays generally broken up into spots......................Subgenus *Decurambis*.

### Subgenus Prolasmidonta Ortmann (1914).

Ortmann, 1914, p. 44.

Type *Unio heterodon* Lea.

There is only one species in this subgenus.

ALASMIDONTA (PROLASMIDONTA) HETERODON (Lea) (1830).

*Alasmidonta heterodon* (LEA) SIMPSON, 1914, p. 499; *Alasmidonta* (*Prolasmidonta*) *heterodon* (LEA) ORTMANN, 1914, p. 44.

Plate XII, figs. 1, 2.

*Records from Pennsylvania:*

Lea, 1830 (Schuylkill River and Darby Creek, the latter chiefly in Delaware Co.)
Conrad, 1838 (Schuylkill River).
Gabb, 1861 (Schuylkill River, below Fairmont Dam, Philadelphia.)
Hartman & Michener, 1874 (Schuylkill River, Chester Co.)
Marshall, 1895 (Philadelphia).
Schick, 1895 (Schuylkill Canal at Philadelphia and Manayunk; Neshaminy Creek, Bucks Co.)
Ortmann, 1909*b*, p. 207.

*Characters of the shell:* Shell small and rather thin. Outline subrhomboidal or subtrapezoidal to subovate, and more or less elongate, rounded anteriorly, subangular behind, with an upper posterior angle (which may be obsolete), and a more distinct and produced lower posterior angle. Lower margin gently curved (chiefly in the male), or straight and even slightly concave (chiefly in the female). Beaks somewhat inflated, but not very prominent, anterior to the middle of the shell, but not very near the anterior end. Beak-sculpture consisting of three or four (rarely traces of a fifth) bars, the first two concentric and simple, the following ones with a distinct angle upon the posterior ridge, in front of which is a more or less distinct, shallow sinus. The bars are moderately heavy and blunt, and the sinus never assumes the shape of a re-entering angle, sometimes it is barely indicated. Thus the beak-sculpture cannot be called double-looped. Upon the posterior slope there are one or two fine radiating lines, indicating as many additional bars, which are obliterated on the disk.

Shell more or less swollen and inflated, chiefly in the region of the posterior ridge, and in the female; the sides are rather flat. Posterior ridge quite distinct, generally more so in the female than in the male, but also in the latter this ridge is distinct, although rounded. In the female, it becomes almost angular. The posterior slope is somewhat compressed in the male, while in the female it appears sometimes almost truncated.

Epidermis greenish olive to brownish. Sometimes obscure (rarely more distinct), simple and straight rays are present, but in other cases, rays are invisible, and the color of the whole surface is uniform. Often there are indistinct concentric bands of lighter and darker green. Growth-rests indistinct.

Hinge complete, with pseudocardinals and laterals, but teeth rather feeble. Pseudocardinals two in each valve, compressed and crenulated, often the anterior

in the right valve, and sometimes the posterior in the left valve rudimentary. In addition, there is an interdental tooth in the left valve, which may be well-developed and isolated, or may be more or less connected with the posterior pseudo-cardinal, or may be even rudimentary. There is great variation in this respect. Laterals rather thin and short; characteristically there are two laterals in the right, and one in the left valve (just the reverse of the normal condition in the Naiades), but there is considerable variation in the laterals. The upper one is generally not so sharp as the lower one, and the former may be more or less rudimentary, sometimes only for a part of its length. Beak-cavities moderately developed, not deep. Dorsal muscle-scars distinct, in the beak-cavity. Adductor muscle-scars moderately deep anteriorly, faint posteriorly.

Nacre bluish or silvery white, iridescent, and often inclining toward cream-color or yellowish in the beak-cavity; sometimes with greenish or grayish discoloration.

Shells of males and females distinguishable. The male as a rule has a more compressed, and more ovate and elongate shell, with the lower margin gently and uniformly curved, the posterior ridge less sharp, and the posterior slope not truncate; while in the female the shell is more swollen in the region of the posterior ridge and just in front of it; has a more distinct posterior ridge, which renders the posterior slope more truncate, and makes the whole outline of the shell shorter and more trapezoidal. Furthermore in the female the lower posterior angle is more produced downward, so that the lower margin of the shell becomes rather straight, in some cases even concave. In young specimens the sexual differences of the shell are not seen, and prevalently the young females in shape resemble males.

| | | L. | H. | D. |
|---|---|---|---|---|
| *Size:* | 1. Kunkletown, Cat. No. 61.4652 (♂) | 48 mm. | 27 mm. | 19 mm. |
| | 2. Manayunk, Cat. No. 61.4250 (♂) | 42 " | 23 " | 14 " |
| | 3. do. Cat. No. 61.4249 (♀ gravid) | 40 " | 23 " | 16 " |
| | 4. do. Cat. No. 61.4250 (♂) | 38 " | 21 " | 14 " |
| | 5. do. " " do. (♀ gravid) | 38 " | 21 " | 15 " |
| | 6. do. Cat. No. 61.4249 (♀ gravid) | 35 " | 20 " | 14 " |

*Soft parts* (See Ortmann, 1912, p. 295). *Glochidia* (See Ortmann, 1911*b*, Pl. 89, fig. 8).

*Breeding season:* Conner (1909, p. 112) found this species gravid in February, and I found gravid females with glochidia on April 24, 1909.

*Remarks:* A small species, easily overlooked, with no striking external features. However, the general shape, chiefly the distinct posterior ridge, give it the un-

mistakable aspect of an *Alasmidonta*. If attention is paid to the hinge, there can be no mistaking this shell, for the teeth are unique, at least among Pennsylvanian shells.

There are no species related to this in western Pennsylvania, and this species has altogether a rather isolated position in the system (See Ortmann, 1913*a*, pp. 324, 361).

*Localities represented in the Carnegie Museum:*

Delaware River, Shawnee, Monroe Co., Pennsylvania.
Princess Creek, Kunkletown, Monroe Co., Pennsylvania.
Schuylkill Canal, Manayunk, Philadelphia Co., Pennsylvania.
Marsh Run, three miles S. E. of Remington, Fauquier Co., Virginia (Rappahannock-drainage).
Mountain Run, Culpeper, Culpeper Co., Virginia (Rappahannock-drainage).

*Locality represented in the Philadelphia Academy of Natural Sciences:*

Big Neshaminy Creek, "Edderton,"[124] Bucks Co., Pennsylvania (H. W. Fowler).

*Distribution and Ecology* (See fig. 17): *Type locality*, Schuylkill River, Pennsylvania (Lea).

In Pennsylvania this species is decidedly rare. I have found it in large numbers only in the Schuylkill Canal; at other localities only a few were obtained. It is

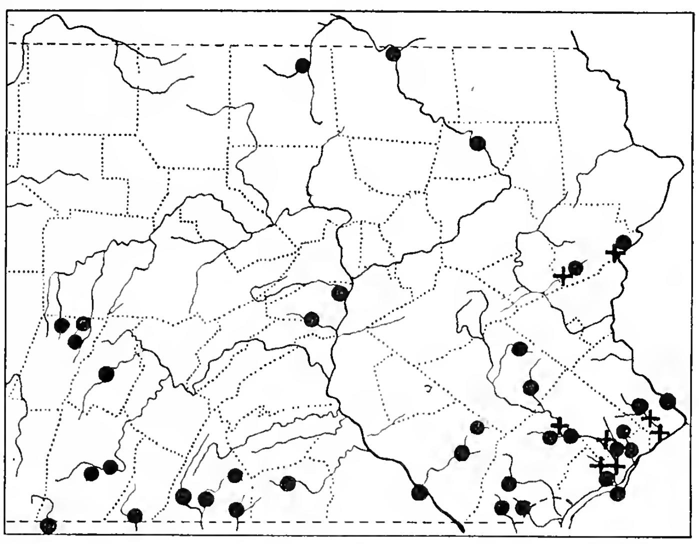

FIG. 17.
+ *Alasmidonta heterodon.*
● *Alasmidonta undulata.*

known from a number of localities in the Delaware-drainage in the vicinity of Philadelphia, and chiefly from streams on the Piedmont Plateau. But in the

[124] Probably = Eddington.

Delaware at Shawnee and at Kunkletown (in a stream tributary to the Lehigh River) I found it to the northwest of the Blue Mountain (Kittatinny Mountain).

No trace of it has ever been seen in the Susquehanna and Potomac drainages, but it is positively present in the Rappahannock-drainage in Virginia, and here again it is on the Piedmont Plateau. (Ortmann, 1913*a*, p. 319.)

According to Simpson (1900), it goes from "northern New England to Virginia," but even in New England and New York locality-records are quite scarce. It is known from the Connecticut River, Hartland, Windsor Co., Vermont (Marshall, 1895), from Massachusetts (Marshall, but not mentioned by Gould-Binney, 1870), and in Connecticut from the Housatonic River (Linsley, 1845) and Mixville (Cheshire) New Haven Co. (Marshall) (see also Johnson, 1915). In New York, it is known from the southeastern portion (Marshall, without exact localities). Otherwise definite records are missing, but the extension of its range southward to Virginia, as given by Simpson, has been confirmed by the present writer with regard to the Rappahannock River.

For the present it may be said that the chief feature of the distribution of this species is its erratic character. As far as I can now see, it seems to be most likely a species of the Piedmont Plateau. Its apparent absence in the Susquehanna and Potomac drainages may be due to the incomplete investigation of the Piedmont tributaries of these rivers.

At Kunkletown and in the Rappahannock-drainage, I found this species in very small streams ("runs"), in strongly flowing water, and in rather coarse gravel, but at each locality only few specimens. In the Delaware at Shawnee it was (one specimen) in a small branch of the river in sand and moderate current. In the only case where I collected large numbers (about fifty), I found it under very different conditions, and that was in the canal at Manayunk at a time when the water had been drained off and only a few inches of water were left in the middle. Here the bottom consisted of larger and smaller stones, the interstices filled with sandy mud. This, however, cannot be regarded as normal, and the ecological conditions of this species remain to be studied.

### Subgenus Alasmidonta Simpson (1900).

*Alasmidonta* Simpson, 1914, p. 493, + *Bullella*, *ibid.*, p. 508; *Alasmidonta* Ortmann, 1914, p. 45.

Type *Monodonta undulata* Say.

Only one species in Pennsylvania belongs to this subgenus.

### Alasmidonta (Alasmidonta) undulata (Say) (1817).[125]

*Alasmidonta undulata* (Say) Simpson, 1914, p. 494.

Plate XI, fig. 7.

*Records from Pennsylvania:*

Say, 1817 (Delaware River).

Gabb, 1861 (Delaware, Schuylkill, and Wissahickon, Philadelphia; headwaters of Frankford Creek, Montgomery Co.)

Bruckhart, 1869 (Lancaster Co.)

Hartman & Michener, 1874 (Chester Co.)

Harn, 1891 (western Pennsylvania).[126]

Schick, 1895 (Canal at Manayunk, Philadelphia Co.; Munckinipattus Creek, Glenolden, Delaware Co.; Neshaminy Creek, Bucks Co.)

Ortmann, 1909*b*, p. 207.

*Characters of the shell:* Shell rather small, and rather thick, chiefly in its anterior part. Outline subtriangular, subovate, or almost subelliptical; generally comparatively short and high, more or less narrowed and pointed behind. Lower margin more or less convex. Upper margin straight, forming or not forming an angle with the obliquely descending posterior margin. Beaks more or less inflated, and somewhat elevated above the hinge-line, situated more or less anteriorly. Beak-sculpture extremely heavy, but somewhat variable. There are specimens with much heavier sculpture than others. Sculpture consisting of four or five bars, which are angular and much elevated posteriorly, straight or very little sinuated in the middle, rounded and low anteriorly, running up to the beaks upon the posterior slope as fine, but distinct, converging lines, and, in addition, there are several similar radiating lines behind them, as well as in front of the beaks. (See Marshall, 1890, fig. 11.) Upon the posterior slope there are sometimes irregular, oblique corrugations, but in most cases, they are absent.

Shell more or less swollen, lateral faces gently convex, with an oblique posterior ridge, which is rounded and often indistinct. Posterior slope somewhat compressed, rarely subtruncate.

Epidermis greenish, yellowish, reddish-brown, brown, or black, with more or less distinct dark green to blackish rays, which are broader or narrower, straight, uninterrupted. Old shells are often uniformly black-brown. Often the posterior slope is lighter than the rest of the shell, with more distinct, sharper, and finer rays. Frequently there are lighter or darker concentric bands. Growth-rests rather indistinct.

[125] Not 1816.

[126] This species certainly is absent from the Ohio-drainage. Harn's specimens may have come from the headwaters of the West Branch of the Susquehanna (See Ortmann, 1909*b*, p. 180).

Hinge incomplete. Pseudocardinals present, stumpy, crenulated, generally one in right, two in left valve, of which the anterior may be rudimentary. Interdental tooth of left valve poorly developed, generally connected with the posterior pseudocardinal. Laterals practically absent. Beak-cavity moderately deep. Dorsal muscle-scars distinct, upon the hinge-plate. Adductor scars deeply impressed anteriorly, less so posteriorly. Nacre white, salmon, pink, or red, the red shades prevailing, very iridescent posteriorly.

Shell of male and female indistinguishable.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Kimberton Dam, Cat. No. 61.883 | 77 mm. | 52 mm. | 37 mm. |
| 2. Tioga, Cat. No. 61.4242 (♀ gravid) | 69 " | 41 " | 28 " |
| 3. do. " " do. (♂) | 56 " | 34 " | 23 " |
| 4. Greencastle, Cat. No. 61.4247 (♀ gravid) | 48 " | 32 " | 18 " |
| 5. do. " " do. (♂) | 42 " | 27 " | 16 " |

*Soft parts* (See Ortmann, 1912, p. 296). *Glochidia* (See Ortmann, 1911*b*, Pl. 89, fig. 9).

*Breeding season:* I have the following dates for gravid females: July 18, 1908; July 22, 1910; Aug. 10, 1910; Aug. 11, 1910; Aug. 12, 1908; Aug. 13, 1910; Aug. 19, 1909; Sept. 5, 1909; Sept. 6, 1909. Then in spring, April 24, 1909; April 26, 1909; May 6, 1912; May 10, 1912; May 11, 1912; June 7, 1912; June 12, 1912; June 14, 1910.

This is clearly a *bradytictic* form, with a rather short interim, in June and July.

*Remarks:* Quite a well characterized species, not to be confounded with any other Pennsylvanian form, and having no related forms in the interior drainage system. The most nearly allied species are found in the southern parts of the Atlantic watershed, South Carolina and Georgia. It is easily recognized by the shape of the shell, heavy beak-sculpture, by the color and markings of its epidermis, and, on the inside of the shell, by the peculiar character of the hinge, and the often beautifully red tints of the nacre.

It is a rather variable shell, and the chief variations have been alluded to above.

*Pennsylvanian localities, represented in the Carnegie Museum:*

*Delaware-drainage:*

Delaware River, Yardley, Bucks Co.; Shawnee, Monroe Co.

White Clay Creek, Avondale, Chester Co.

Schuylkill Canal, Manayunk, Philadelphia Co.

Kimberton Dam, Chester Co. (Hartman collection) (formed by French Creek, near Phoenixville, Chester Co.)

Princess Creek, Kunkletown, Monroe Co.

*Susquehanna-drainage:*

Susquehanna River, Selinsgrove, Snyder Co.
Muddycreek, Lancaster Co. (G. H. Clapp, donor) (drainage of Conestoga Creek).
Conewago Creek, Table Rock, Adams Co.
Conodoguinet Creek, Carlisle, Cumberland Co.
Frankstown Branch Juniata River, Hollidaysburg, Blair Co.
Raystown Branch Juniata River, Everett, Bedford Co.
Shobers Run, Bedford Springs, Bedford Co. (A. Koenig).
West Branch Mahantango Creek, Richfield, Juniata Co. (D. A. Atkinson).
Beaver Dam Creek, Flinton, Cambria Co. (D. A. Atkinson).
Swartz Run, Ashville, Cambria Co.
Chest Creek, Patton, Cambria Co.
North Branch Susquehanna River, Tunkhannock, Wyoming Co.
Chemung River, South Waverly, Bradford Co.
Mill-race of Crooked Creek, Tioga, Tioga Co.

*Potomac-drainage:*

East Branch Little Antietam Creek, Waynesboro, Franklin Co.
Conococheague Creek, Greencastle and Scotland, Franklin Co.
West Branch Conococheague Creek, Mercersburg Junction, Franklin Co.
Great Tonoloway Creek, Thompson Township, Fulton Co.

*Pennsylvanian localities represented in the Philadelphia Academy of Natural Sciences:*

Manatawny Creek, Earlville, Berks Co. (H. A. Pilsbry).
Sacony Creek, Kutztown, Berks Co. (H. K. Deisher).
Schuylkill River, Phoenixville, Chester Co. (C. M. Wheatley).
"Valley Creek,"[127] southwest of Coatesville, Chester Co. (C. H. Conner).
"Big Elk Creek, Westgrove,"[128] Chester Co. (C. H. Conner).
Lancaster, Lancaster Co. (J. B. Eshleman).
Pequea Creek, Paradise, Lancaster Co. (W. Stone).
Susquehanna River, York Furnace, York Co. (W. Stone).

*Other localities, represented in the Carnegie Museum:*

Aroostook River, Caribou, Aroostook Co., Maine (O. O. Nylander).
Fish River, Eagle Lake, Aroostook Co., Maine (O. O. Nylander).
Delaware River, Newbold, Gloucester Co., New Jersey (C. H. Conner).
Potomac River, Hancock, Washington Co., Maryland.
Wills Creek, Ellerslie, Allegany Co., Maryland.
South Branch Potomac River, Romney, Hampshire Co., West Virginia.
Shenandoah River, Harpers Ferry, Jefferson Co., West Virginia.
North Fork Shenandoah River, Broadway, Rockingham Co., Virginia.
South Fork Shenandoah River, Elkton, Rockingham Co., Virginia.

[127] Probably Sucker Run, tributary to West Branch Brandywine Creek.

[128] Not exact. The Middle Branch of White Clay Creek is at Westgrove and Big Elk Creek is about four or five miles farther West, at Lincoln University.

South River, Waynesboro, Augusta Co., Virginia.
Rappahannock River and Marsh Run, Remington, Fauquier Co., Virginia.
North River, Buena Vista and Lexington, Rockbridge Co., Virginia.
Calf Pasture River, Goshen, Rockbridge Co., Virginia.

*Distribution and Ecology in Pennsylvania* (See fig. 17): A common species in the Atlantic-drainage in Pennsylvania; but it is quite evident that it avoids the larger rivers, and prefers the smaller streams, where it becomes locally very abundant, going far up towards the headwaters, as is best seen in the upper Juniata and the tributaries of the West Branch of the Susquehanna in Cambria Co. Here it closely approaches the divide, but in no instance has it been found west of the divide.

It does not seem to favor riffles and very rough water, but is found chiefly in more quiet parts, but with some current, for instance, above riffles, where a steady flow of water prevails. It does not like slackwater, but occasionally it is found in ponds and canals; and it has been reported from several lakes in New York. It also likes mill-races, if the current is not too rapid. It lives mostly in a mixture of coarser or finer gravel with sand and mud; but I have taken it also in eddies with slow current embedded in the mud deposited between larger stones.

*General distribution: Type locality,* Delaware River, near Philadelphia (Say).

According to Simpson (1900), this species extends from the "Lower St. Lawrence-drainage southward to North Carolina." Its presence in the lower St. Lawrence (below Lake Ontario) is well established (Bell, 1859; Whiteaves, 1863; Marshall, 1895). In New York state it is found in the St. Lawrence-drainage, as in Lake Champlain (De Kay, 1843), Seneca and Crooked Lakes (Dewey, 1856); and in Onondago Co. (Marshall). It is more abundant still in the drainage of the Mohawk and Hudson Rivers, and of the upper Susquehanna (Chenango, Canisteo, Conhocton, and Tioga Rivers) (See De Kay, 1843; Lewis, 1860; Marshall, 1895).

It has been reported from Maine (Lermond, 1909; Nylander, 1914), from Keene, Cheshire Co., New Hampshire (Walker & Coolidge, 1908), and is rather common in Vermont (Adams, 1842), Massachusetts (Gould-Binney, 1870), Rhode Island (Carpenter, 1890), Connecticut (Linsley, 1845; Perkins, 1869) (See also Johnson, 1915, p. 26).

South of Pennsylvania it has been previously recorded from Sideling Creek, Allegany Co., Maryland (Pilsbry, 1894), and from Raleigh, Wake Co., North Carolina (Marshall, 1895), but other exact localities are not known to me. However that it exists in the Potomac, Rappahannock, and upper James drainages is shown by the material collected by myself for the Carnegie Museum.

The exact southern boundary of this species in North Carolina is unknown. Although its metropolis seems to be in the northern parts of the Atlantic watershed, we have reason to believe, on account of its southern affinities, that it belongs to the southern element in the Atlantic fauna (Ortmann, 1913*a*, pp. 324 and 361).

### Subgenus Decurambis Rafinesque (1831).

*Rugifera* Simpson, 1900, p. 670; 1914, p. 504; Ortmann, 1914, p. 46; *Decurambis* Frierson, 1914*a*, p. 7.

Type *Alasmodonta marginata* Say.

Two species and one variety belong here.

#### Key to the Forms of Decurambis.

$a_1$. Posterior slope strongly truncate. Beaks placed more centrally, anterior end of shell more produced.

$b_1$. Shell greenish, posterior slope slightly lighter than the rest, but generally with rays. *A.* (*D.*) *marginata*.

$b_2$. Shell with posterior slope contrasted with the rest, light or reddish brown, hardly with rays. Rest of the shell brownish or yellowish, with distinct green rays. *A.* (*D.*) *marginata susquehannæ*.

$a_2$. Posterior slope less strongly truncate. Beaks placed more anteriorly, and anterior end of shell shorter. . . . . . . . . . . . . . . . . . . . . *A.* (*D.*) *varicosa*.

### Alasmidonta (Decurambis) marginata (Say) (1819).

*A. truncata* (B. H. Wright) Simpson, 1900, p. 671; *A. marginata* (Say) Fox, 1901, p. 47; *Alasmidonta marginata* (Say) Simpson, 1914, p. 504.

Plate XII, fig. 3.

*Records from Pennsylvania:*

Harn, 1891 (western Pennsylvania).
Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co.; Beaver River, Wampum, Lawrence Co.)
Ortmann, 1909*b*, p. 196.

*Characters of the shell:* Shell of medium size, moderately thick, but rather thin when young. Outline subtrapezoidal, rounded before and triangular behind. Lower margin gently convex, more or less straight, or even somewhat concave in the posterior part. Upper margin straight or gently convex, forming a more or less distinct angle with the obliquely descending posterior margin. Beaks large and inflated, somewhat elevated above the hinge-line, situated somewhat in front of the middle, but at a considerable (although variable) distance from the anterior end. Beak-sculpture heavy, consisting of three or four thick bars, the second and third being a little produced and angular upon the posterior ridge, and having a more or less distinct sinus in front of the angle. This sinus is quite variable, some-

times rather distinct, so as to render the bars almost double-looped, sometimes hardly indicated, so that the middle part of the bars is almost straight. The fourth bar, if present at all, is rudimentary, and only its middle part is distinct. Radiating lines upon the posterior slope indistinct or absent. But upon the posterior slope there is a system of fine, irregular, radial wrinkles or ridges, running toward the upper posterior margin. These wrinkles are rarely absent or obscure, but generally well-developed; they may be finer or coarser, and may extend over a larger or smaller portion of the posterior slope; generally they are less distinct toward the posterior end in old shells.

Shell inflated, greatest width at or immediately in front of the posterior ridge. Lateral faces gently convex, with a very distinct posterior ridge, which, although rounded, is well marked in consequence of the truncated character of the posterior slope. Very often the posterior ridge appears as if bounded by two ridges, including an elevated part of the shell between them: this is chiefly the case toward the posterior end of old shells. The posterior slope is somewhat compressed and elevated in the middle, but in its general shape it presents a truncate, in some cases almost flat appearance.

Epidermis yellowish, greenish, or brownish, blackish in old shells, generally with very distinct greenish or blackish rays. Rays narrow or wide, straight, in most cases more or less broken up into (or overlaid by) darker spots. The spots are best developed towards the beaks, but often they are distinct all over the shell, and very rarely entirely wanting. Generally, the posterior slope is lighter in color than the rest of the shell, and has fewer and less distinct rays and spots. Often there are also lighter and darker concentric bands, marking, more or less, the growth-rests. In old shells, the color pattern becomes obscure, and the shell is more or less uniformly blackish.

Hinge incomplete. Pseudocardinals rather thin, but distinct, depressed-triangular (not stumpy), one in each valve, and the left valve has, in addition, a more or less well-developed interdental tooth, which may be separated from the pseudocardinal, or more or less united with it. More rarely it is rudimentary. Lateral teeth absent. Beak-cavity moderate. Dorsal muscle-scars in the beak-cavity upon the hinge-plate. Adductor-scars distinct and rather deeply impressed anteriorly, less so posteriorly.

Nacre bluish white, sometimes in places greenish or grayish, discolored, iridescent posteriorly, rarely with very pale salmon tints, never distinctly pinkish or reddish.

Shell of the female hardly distinguishable from that of the male. Some

shells are more inflated over the posterior ridge than others, and when this swelling reaches considerable proportions, we may be assured that we have to deal with a female. But not all females have this inflation, and often males are more inflated than females of the same size.

| | L. | H. | D. | Distance of beaks from anterior end. | Pr.ct. of length. |
|---|---|---|---|---|---|
| *Size:* 1. Shenango, Cat. No. 61.4270 (♂) | 96 mm. | 56 mm. | 35 mm. | 34 | .35 |
| 2. do. " " do. (♀ gravid) | 92 " | 53 " | 40 " | 29 | .32 |
| 3. Rose Point, Cat. No. 61.3139 (♂) | 81 " | 42 " | 38 " | 26 | .32 |
| 4. do. " " do. (♀ gravid) | 73 " | 39 " | 27 " | 22 | .30 |
| 5. do. " " do. (♂) | 68 " | 39 " | 28 " | 23 | .34 |
| 6. do. " " do. (♀ gravid) | 63 " | 36 " | 26 " | 21 | .33 |

From the above table it is seen that the females are not always more swollen than the males. The location of the beaks is at about one-third of the length of the shell from the anterior end.

*Soft parts* (See Ortmann, 1812, p. 297). *Glochidia* figured by Lea (Obs. VI, 1858, Pl. 5, fig. 27) and Surber (1912, Pl. 3, fig. 42). Surber's measurements are: 0.35 × 0.38, while mine are: 0.33 × 0.36 mm.

*Breeding season:* My records for breeding females cover the time from July 19 (eggs) till October 23. The earliest date for glochidia is September 2. It is to

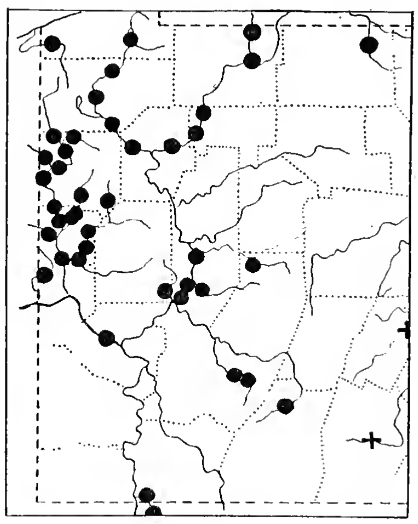

FIG. 18.

● *Alasmidonta marginata.*
+ *A. marginata susquehannæ.*

be regretted that no dates are at hand for the spring months, but the species is undoubtedly bradytictic.

*Remarks:* This species is easily recognized and distinguished from others of the genus by the general shape, sculpture of the posterior slope, color of the epidermis, and by the hinge-teeth. There is no anodontine shell, except *Alasmidonta varicosa*, which could be confounded with it, but it bears an external and superficial resemblance in shape and color to a lampsiline shell, *Truncilla triquetra* Rafinesque. The latter, however, is much smaller and has a different hinge.

The typical form of *A. marginata* is a western shell. It is rather variable in shape. Its chief characters are its size, strongly truncate posterior end, and, in consequence of this, the more median position of the beaks, with the anterior end of the shell more developed. In this it is distinguished from its eastern representative, *A. varicosa*. But there are shells found in western Pennsylvania, chiefly in the mountain-streams, in which the truncation of the posterior end is not so pronounced. The existence of a peculiar race in the Susquehanna-drainage will be discussed below (See under var. *susquehannæ*).

Specimens from Conneaut Creek (drainage of Lake Erie) do not differ from the typical *A. marginata*.

*Pennsylvanian localities represented in the Carnegie Museum:*

*Ohio- and Beaver-drainages:*

Little Beaver Creek, Cannelton, Beaver Co. (Miss Vera White & H. H. Smith).
Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Connoquenessing Creek, Ellwood City, Lawrence Co. (G. H. Clapp & H. H. Smith).
Slipperyrock Creek, Wurtemberg and Rose Point, Lawrence Co.
Wolf Creek, Grove City, Mercer Co.
Mahoning River, Mahoningtown, Lawrence Co.
Neshannock Creek, Eastbrook and Volant, Lawrence Co.; Leesburg, Mercer Co.
Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Sharpsville, Clarksville, Shenango, and Jamestown, Mercer Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Little Shenango River, Greenville, Mercer Co.

*Allegheny-drainage:*

Allegheny River, Godfrey, Kelly, and Templeton, Armstrong Co.; Walnut Bend, Venango Co.; Tionesta, and Hickory, Forest Co.; Warren, Warren Co.; Larabee, McKean Co. (Dennis Dally).
Buffalo Creek, Harbison, Butler Co.
Loyalhanna River, Idlepark and Ligonier, Westmoreland Co.
Quemahoning Creek, Stanton's Mill, Somerset Co.
Crooked Creek, Rosston, Armstrong Co.
Little Mahoning Creek, Goodville, Indiana Co.
French Creek, Utica, Venango Co.; Cochranton, Meadville, and Cambridge Springs, Crawford Co.
Leboeuf Creek, Waterford, Erie Co.
Connewango Creek Russell, Warren Co.

*Monongahela-drainage:*

Cheat River, Cheat-Haven, Fayette Co.

*Lake Erie-drainage:*

Conneaut Creek, West Springfield, Erie Co.

*Other localities represented in the Carnegie Museum:*

*Lake-drainage:*

Conestogo River, Conestogo, Waterloo Co., Ontario, Canada (Miss Maria Jentsch).[129]
Sandusky River, Upper Sandusky, Wyandot Co., Ohio (C. Goodrich).
Maumee River, Waterville, Lucas Co., and Defiance, Defiance Co., Ohio (C. Goodrich); Fort Wayne, Allen Co., Indiana (C. Goodrich).

*Ohio-drainage:*

Tuscarawas River, Ohio (Holland collection).
Cheat River, Jaco and Mount Chateau, Monogalia Co., West Virginia.
West Fork River, Lynch Mines, Harrison Co.; Weston, Lewis Co., West Virginia.
Little Kanawha River, Grantsville, Calhoun Co., West Virginia (W. F. Graham).
North Fork Hughes River, Cornwallis, Ritchie Co., West Virginia.
Elk River, Shelton, Clay Co.; Gassaway, Braxton Co., West Virginia.
Greenbrier River, Ronceverte, Greenbrier Co., West Virginia.
Reed Creek, Wytheville, Wythe Co., Virginia.

*Tennessee-drainage:*

Bear Creek, Burleson, Franklin Co., Alabama (H. H. Smith).
Shoals Creek, Lauderdale Co., Alabama (H. H. Smith).
Elk River, Fayetteville, Lincoln Co., Tennessee (H. H. Smith).
Flint River, Gurley, Madison Co., Alabama (G. H. Clapp, donor).
Paint Rock River, Paint Rock and Trenton, Jackson Co., Alabama (H. H. Smith).
Holston River, Mascot, Knox Co.; Hodges, Jefferson Co.; Turley Mill and Holston Station, Grainger Co.; Austin Mill, Hawkins Co., Tennessee.
South Fork Holston River, Pactolus, Bluff City, and Emmett, Sullivan Co., Tennessee.
Middle Fork Holston River, Chilhowie, Smyth Co., Virginia.
North Fork Holston River, Rotherwood, Hawkins Co., Tennessee; Hilton, Scott Co., Virginia; Mendota, Washington Co., Virginia; Saltville, Smyth Co., Virginia.
Big Mocassin Creek, Mocassin Gap, Scott Co., Virginia.
Clinch River, Edgemoor and Clinton, Anderson Co.; Black Fox Ford, Union Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Speers Ferry and Clinchport, Scott Co., Virginia; St. Paul, Wise Co., Virginia; Fink and Cleveland, Russel Co., Virginia; Richland, Tazewell Co., Virginia.
Powell River, Combs, Claiborne Co., Tennessee; Dryden, Lee Co., Virginia.

*West of Mississippi:*

Gasconade River, Gasconade, Gasconade Co., Missouri (W. I. Utterback).
James River, Galena, Stone Co., Missouri (A. A. Hinkley).
White River, Cotter, Baxter Co., Arkansas (A. A. Hinkley).

[129] Grand River-drainage, to Lake Erie. The specimen at hand is normal.

*Distribution and Ecology in Pennsylvania* (See fig. 18): This species is rather frequent in the Ohio-drainage in western Pennsylvania, but decidedly avoids the larger rivers, and is more or less absent (probably extinct) in the Monongahela-drainage. Rhoads mentions it from the Ohio at Coraopolis, below Pittsburgh, but I never found it in the Ohio proper, nor in the Allegheny below Armstrong Co. In the Ohio between Pennsylvania and Cincinnati it is also missing. In the Monongahela-drainage it has been found only in Cheat River, but it turns up again in the upper Monongahela system (Cheat and West Fork Rivers) in West Virginia.

In the Beaver-drainage, this species is abundant, except in the extreme headwaters. From Armstrong County upwards it is found regularly in almost all streams tributary to the Allegheny, and goes far up into the upper Loyalhanna in Westmoreland Co., the Quemahoning in Somerset Co., the Little Mahoning in Indiana Co., and the uppermost Allegheny in McKean Co.

*A. marginata* is most decidedly a species of the riffles, being found there in finer or coarse, but firmly packed gravel, in swift currents. It is one of the species, which in the Conemaugh-drainage enter the valleys between Chestnut and Laurel Ridges and the Allegheny Front.

It occurs also in Conneaut Creek of the Lake Erie-drainage. Here it is rather abundant, and does not differ at all from the common form of western Pennsylvania. It should be noted that it never has been found on the Pennsylvanian shores of Lake Erie, although Sterki (1907*a*) reports a small, slight form, from the lake in Ohio, and Walker (1913, p. 22) reports *A. varicosa* from Lake Erie. I have never seen this lake-form.

Call (1900) remarks on the strongly developed foot of this species, which is, indeed, quite remarkable. When fully extended, the foot is firmly attached to the gravel in the river bed, and it requires quite an effort to dislodge the specimens.

*General distribution: Type locality,* Scioto River, Chillicothe, Ross Co., Ohio, Say. (See Fox, 1901.)

Simpson (1900) gives this species as from the "Upper Mississippi-drainage; Ohio, Cumberland, and Tennessee river systems; Michigan; Upper St. Lawrence-drainage." This is about right, but it should be noted that the species advances eastward into certain mountain-streams of the western slope of the Alleghenies, not only in the headwaters of the Tennessee in Tennessee and Virginia, but also in West Virginia and Pennsylvania, in the upper Kanawha system, and in the upper Conemaugh. In the Allegheny it also goes far up (to Olean, Cattaraugus Co., New York) (Marshall, 1895) and to McKean Co., Pennsylvania. It is known from several other localities in western New York, partly in the St. Lawrence,

partly in the Atlantic-drainage (Marshall and Baker, 1898*b*), but these records should be confirmed on account of the possibility, that this form may have been confounded with the eastern forms.[130] Thus the northeastern boundary of *A. marginata* is yet obscure. Northward this species has certainly crossed over into the lake-drainage, as is shown by a number of localities represented in the Carnegie Museum, and has been reported for Ohio (Dean, 1890; Sterki, 1907*a*), Indiana (Call, 1896*a* and 1900), and Illinois (Baker, 1898*a*, 1906). In Michigan, it has spread over the southern parts of the state, as far north as Roscommon Co. (Walker, 1898), and it is present in Ontario, north of Lake Erie (Carnegie Museum).

In the Mississippi this species goes up from Iowa (Pratt, 1876; Witter, 1878) to Minnesota (Grant, 1886; Holzinger, 1888).

West of the Mississippi, it seems to be much rarer. It is in the Wapsipinicon and Volga Rivers in Iowa (Geiser, 1910), and at Iowa City, Johnson Co., Iowa (Marshall), in Missouri (Utterback, 1916), but not in Kansas (Scammon, 1906). It is in the Ozark region of northern Arkansas (Carnegie Museum and Meek & Clark, 1912) going to the Ouachita River in central Arkansas (Wheeler, 1918). Thence southward it is missing.

### ALASMIDONTA (DECURAMBIS) MARGINATA SUSQUEHANNÆ Ortmann.

Ortmann, 1913*b*, p. 315 (*et passim, sine descriptione*).

Plate XII, fig. 4.

Not previously recorded, except by Ortmann (1913*b*).

*Characters of variety:* Shell somewhat smaller than that of the normal form. Color of epidermis peculiar, brighter. Epidermis more or less brown (pale or reddish brown), with distinct green rays, which have a very strong tendency to break up into spots, which are very rarely absent. The posterior slope is always light in color, pale brown, reddish or yellowish, with hardly any green rays, so that it is in sharp contrast to the rest of the shell.

The nacre is whitish, but has quite frequently salmon or pinkish tints, in fact, delicate reddish tints are the rule in this variety, while the bluish-white of the western *marginata* is rarely present.

Finally the posterior truncation, although similar to that of many specimens of the western form, does not exhibit the extreme development, which is so often seen in the latter.

[130] Marshall, for instance, cites the Chemung and Tioga Rivers, belonging to the Susquehanna-drainage. The Carnegie Museum possesses specimens from the Tioughnioga River, Susquehanna-drainage, which surely are not typical *marginata*, but belong to the two eastern forms, var. *susquehannæ*, and the species *varicosa*.

Otherwise this form is like the western *marginata,* and differs markedly from the common eastern *A. varicosa,* with which it is sometimes found associated.

| | L. | H. | D. | Distance of beaks from anterior end. | Pr.ct. of length. |
|---|---|---|---|---|---|
| *Size:* 1. Carlisle, Cat. No. 61.4677 (♀ gravid).... | 79 mm. | 41 mm. | 30 mm. | 23 mm. | .29 |
| 2. do. " " do. (♂).......... | 71 " | 39 " | 28 " | 22 " | .30 |
| 3. do. " " do. (♀ gravid).... | 69 " | 36 " | 29 " | 23 " | .33 |
| 4. Selinsgrove, Cat. No. 61.4679 (♀ gravid). | 66 " | 35 " | 26 " | 19 " | .29 |
| 5. do. " " do. (♂)....... | 61 " | 36 " | 28 " | 20 " | .33 |
| 6. do. " " do. (♂)....... | 47 " | 26 " | 17 " | 14.5 " | .31 |

*Soft parts* and *glochidia* identical with those of *A. marginata.*

*Breeding season:* The following records for gravid females are at hand: Aug. 13, 1908; Aug. 13, 1910; Aug. 14, 1910; Aug. 20, 1909; Aug. 20, 1909; Aug. 21, 1909; Sept. 8, 1909.

These dates indicate only the beginning of the breeding season early in August (eggs and glochidia found on first date!). Thus it is probably bradytictic.

*Remarks:* This is a new form, which has not been distinguished previously. It comes very near to the western *A. marginata* in shape, having a rather sharp posterior ridge and a more or less distinctly truncated posterior slope, and having the beaks nearer to the middle of the shell (at about one third of the length of the shell). It is practically a *marginata* in shape with a peculiar color, and is thus more closely allied to the western shell than to the eastern *A. varicosa,* and its presence on the Atlantic side is highly interesting.

Wherever this form is found associated with the eastern *varicosa,* the two may be distinguished at a glance, *varicosa* being smaller, with posterior ridge and posterior truncation less developed, and with generally a darker epidermis, without distinct spots, and the posterior slope not lighter, but rather darker than the rest of the shell.

*Localities represented in the Carnegie Museum:*

Susquehanna River, Duncannon, Perry Co., Pennsylvania.

Susquehanna River, Selinsgrove, Snyder Co., Pennsylvania.

Conodoguinet Creek, Carlisle, Cumberland Co., Pennsylvania.

Juniata River, Juniata Bridge, Perry Co., Pennsylvania.

Frankstown Branch Juniata River, Huntingdon and Alexandria, Huntingdon Co., Pennsylvania. (D. A. Atkinson).

Raystown Branch Juniata River, Ardenheim, Huntingdon Co.; and Mount Dallas, Bedford Co., Pennsylvania.

Penns Creek, Selinsgrove, Snyder Co., Pennsylvania.

North Branch Susquehanna River, Tunkhannock, Wyoming Co., Pennsylvania.

Chemung River, South Waverly, Bradford Co., Pennsylvania.
Tioughnioga River, Cortland, Cortland Co., New York (H. H. Smith) (drainage of upper North Branch Susquehanna).

*Localities represented in the Philadelphia Academy of Natural Sciences:*

Juniata River, Tuscarora, Juniata Co. (S. N. Rhoads); Newton-Hamilton, Mifflin Co. (H. T. Mather, Jr.); Mount Union, Huntingdon Co., Pennsylvania (S. N. Rhoads).

*Distribution and Ecology* (See figs. 18 & 19): *Type locality,* Susquehanna River, Selinsgrove, Snyder Co., Pennsylvania. *Type set:* Carnegie Museum Cat. No. 61.4679.

The above localities are all that are known, and they are restricted to the Susquehanna-drainage in Pennsylvania and New York. The form goes up the North Branch and its tributaries, reaching at least to Cortland, New York, and down the Susquehanna as far as the vicinity of Harrisburg (Duncannon). In addition, it is found in Conodoguinet Creek and the Juniata River. In the latter it ascends rather far (Mt. Dallas, Bedford Co.).

It should be noted, that it has not yet been found in the West Branch of the Susquehanna; the few individuals at hand from the West Branch-drainage are

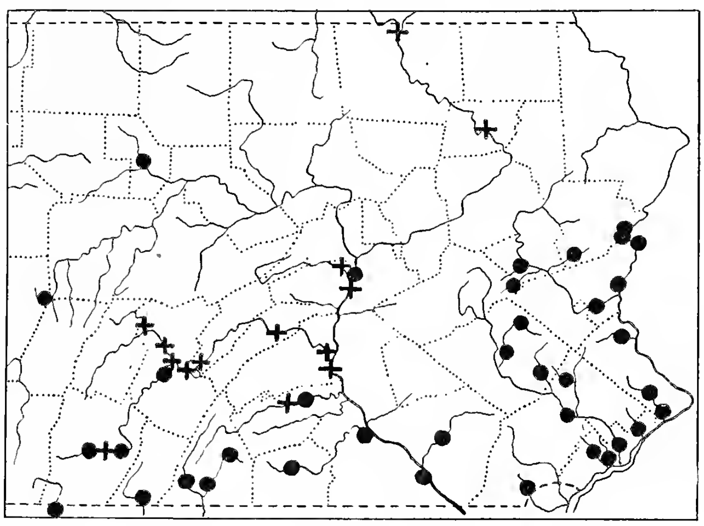

FIG. 19.
+ *Alasmidonta marginata susquehannæ.*
● *Alasmidonta varicosa.*

all *A. varicosa.* However, this section of the Susquehanna system is poorly known, and most of it is badly polluted by mine-water and refuse from tanneries. Below Harrisburg, in the part of the Susquehanna which traverses the Piedmont Plateau, and in its tributaries in that region, this form has not been observed.

The ecological habits of this variety are identical with those of the western

*marginata.* It frequents riffles, and this renders it the more conspicuous, since there are few species on the Atlantic side which *prefer* this habitat.

According to our present knowledge, *A. marginata susquehannæ* is most abundant in the Juniata River, and those parts of the Susquehanna system, which are within the Allegheny Mountains. There is no trace of it in the Delaware or Potomac drainages.

The peculiar features of the distribution suggest the idea, that this form came from the West by crossing the Alleghenian divide. This has been discussed elsewhere (Ortmann, 1913*a*, pp. 370 *et seq*).

### Alasmidonta (Decurambis) varicosa (Lamarck) (1819).

*Alasmidonta marginata* Simpson, 1900, p. 670; *Alasmidonta varicosa* (Lamarck) Pilsbry, 1901, p. 17; *Alasmidonta varicosa* (Lamarck) Simpson, 1914, p. 506.

Plate XII, fig. 5.

*Records from Pennsylvania:*

Lamarck, 1819 (Schuylkill River, Philadelphia).
Lea, Obs. II, 1838, p. 56 (Crum Creek, Delaware Co.)[131]
Bruckhart, 1869 (Lancaster Co.).
Hartman & Michener, 1874 (Chester Co.)
Marshall, 1895 (Philadelphia).
Schick, 1895 (Tohickon Creek, Bucks Co.; Neshaminy Creek, Bucks Co.; Munckinipattus Creek, Glenolden, Delaware Co.)
Ortmann, 1909*b*, p. 207.
Caffrey, 1911 (Delaware River, Northampton Co.)

*Characters of the shell:* The shell of this species differs from that of *A. marginata* by its smaller size, and by the outline, which is rather more subovate than subtrapezoidal, and slightly more elongate on the average. This difference of the outline is brought about by a different development of the posterior ridge and posterior slope. The posterior ridge is not so sharp, more broadly rounded, and often appears biangulate,[132] and the posterior slope is not so distinctly truncate. This renders the whole posterior section of the shell more elongated and rounded, and in consequence the anterior section is comparatively less developed, so that the beaks are situated more anteriorly, generally at a distance from the anterior end of considerably less than one-third of the length of the shell.

The color of the epidermis is much like that of *A. marginata,* with the darker

[131] By a mistake I have given this record (*Margaritana marginata*) under *Strophitus undulatus* (Ortmann, 1909*b*, p. 205).

[132] Indications of the biangulate character is sometimes found also in the western *A. marginata.*

green shades prevailing. There is sometimes a light (brownish) ground-color, with the rays not very strongly marked, but generally the dark green rays prevail, and often the whole shell becomes dark green or blackish. The rays do not possess a strong tendency to break up into spots, and are generally straight and simple, but of various widths. Distinct spots are rarely seen. The posterior slope is rarely lighter than the rest of the shell, and if so, the contrast is not well-marked; but, on the contrary, the posterior slope often appears slightly darker than the rest of the shell, which is due to a stronger development of dark green rays upon it. Nacre whitish or bluish-white, very often with salmon, pinkish, or purplish shades, which, however, are not very intense. Otherwise the shell is like that of *A. marginata.*

The female shells are slightly more swollen in the region of the posterior ridge. In old shells, this swelling is sometimes very distinct, and goes so far, that the lateral faces of the shell, in front of the ridge, appear flat or even concave, which concavity corresponds to a slight emargination of the lower margin.[133] However, sometimes males also show a slightly concave margin, and in many cases the sex cannot be positively recognized by the characters of the shell, since not all females have that swelling, and since the latter is sometimes also present in males.

| | L. | H. | D. | Distance of beaks from anterior end. | Pr.ct. of length. |
|---|---|---|---|---|---|
| *Size:* 1. Ridley Creek, Cat. No. 61.4680 (♂) | 70 mm. | 38 mm. | 29 mm. | 18 mm. | .26 |
| 2. Kunkletown, Cat. No. 61.4671 (♀) | 69 " | 36 " | 26 " | 17 " | .25 |
| 3. do. " " do. (♂) | 62 " | 36 " | 22 " | 17 " | .27 |
| 4. Greencastle, Cat. No. 61.4675 (♂) | 61 " | 33 " | 24 " | 17.5 " | .29 |
| 5. Carlisle, Cat. No. 61.5873 (♀ gravid) | 55 " | 31 " | 22 " | 14 " | .25 |
| 6. Mt. Dallas, Cat. No. 61.4266 (♀ gravid) | 45 " | 26 " | 18 " | 12 " | .27 |
| 7. Mantz, Cat. No. 61.4253 (♂) | 45 " | 25 " | 18 " | 12 " | .27 |
| 8. do. " " do. (♀ gravid) | 36 " | 23 " | 15 " | 10 " | .28 |

There is another specimen from Ridley Creek, which is even larger than No. 1 (L. 75 mm.), but it is greatly deformed and freakish in shape, so that the dimensions are entirely abnormal.

The above figures show the more anterior location of the beaks, although the highest value corresponds to the lowest in *A. marginata.*

*Soft parts* and *Glochidia* identical with those of *A. marginata.*

*Breeding season:* Gravid females have been found: Aug. 9, 1910; Aug. 10, 1910; Aug. 11, 1910; Aug. 12, 1910; Aug. 13, 1908; Aug. 13, 1910; Aug. 14, 1910; Sept. 4, 1909; Sept. 5, 1909; Sept. 6, 1909; Sept. 8, 1909; and May 3, 1909.

[133] The concave lower margin is here decidedly more frequent than in *A. marginata.*

Breeding begins in August, when eggs are present; later, in September, glochidia are found. These are carried over the winter, and are still in the marsupium in May; discharge has been observed on May 3.

This species supplements somewhat the incomplete observations on *A. marginata*, and probably the breeding seasons of both species are about identical.

*Remarks:* This species has been frequently misunderstood, and confused with the western *A. marginata.* But Simpson (1900) (following Wright) recognized its specific distinctness, and I now hold the same opinion, although formerly (Ortmann, 1909*b*) I regarded it as a variety of *A. marginata.* But this was before I had realized that there is in the Susquehanna-drainage another form, which actually is more closely related to *A. marginata.*

*A. varicosa* is easily distinguished from *A. marginata* by the size and shape of the shell, and from the var. *marginata susquehannæ* it also differs in color. It is generally much smaller than either of them, and specimens over 60 or 65 mm. in length are quite scarce.

Although there is much variation in shape and color, this species hardly ever inclines toward the western form, and no intergrades are found. I possess only a single individual (dead shell) from White Clay Creek, Avondale, Chester Co., which has a sharper posterior ridge, and a lighter posterior slope, thus inclining toward the var. *susquehannæ*, but it has the general outline of *varicosa*, and, like this, no spots. Being the only individual found at that locality, we cannot draw any conclusions from it.

In the Susquehanna-drainage, I repeatedly found this species associated with *A. marginata susquehannæ*, but had never any difficulty in separating them. That there are two distinguishable forms in this region, was evident to me when I collected them together for the first time (Ardenheim, Aug. 13, 1908), and further study has only confirmed this view, although for a time I followed the views of previous authors.

*Localities in Pennsylvania, represented in the Carnegie Museum:*

*Delaware-drainage:*

Delaware River, Shawnee, Monroe Co.; Northampton Co. (G. W. Caffrey coll., G. H. Clapp donor); Yardley, Bucks Co.

White Clay Creek, Avondale, Chester Co.

Ridley Creek, Delaware Co. (C. H. Conner).

Lehigh River, Bethlehem, Northampton Co. (Holland collection).

Princess Creek, Kunkletown, Monroe Co.

Lizard Creek, Mantz, Schuylkill Co.

Mahoning Creek, Lehighton, Carbon Co.

*Susquehanna-drainage:*

Susquehanna River, York Haven, York Co.; Selinsgrove, Snyder Co.
Conewago Creek, Table Rock, Adams Co.
Conodoguinet Creek, Carlisle, Cumberland Co
Raystown Branch Juniata River, Ardenheim, Huntingdon Co.; Everett and Mount Dallas, Bedford Co.; Bedford, Bedford Co. (A. Koenig).
Driftwood Branch, Sinnemahoning Creek, Driftwood, Cameron Co.
Cush Cushion Creek, Green Township, Indiana Co. (D. A. Atkinson).

*Potomac-drainage:*

Conococheague Creek, Greencastle and Scotland, Franklin Co.
West Branch Conococheague Creek, Mercersburg Junction, Franklin Co.
Great Tonoloway Creek, Thompson Township, Fulton Co.

*Localities represented in the Philadelphia Academy of Natural Sciences:*

Delaware River, Delaware Water Gap, Monroe Co. (S. N. Rhoads), and Columbia, Warren Co., New Jersey (S. N. Rhoads).
Big Neshaminy Creek, Edderton,[134] Bucks Co. (H. W. Fowler).
Pennypack Creek, Holmesburg, Philadelphia Co. (H. W. Fowler).
Swamp Creek, Zieglerville, Montgomery Co. (Bayard Long).
Manatawny Creek, Earlville, Berks Co. (H. A. Pilsbry).
Maiden Creek, Berks Co.
Sacony Creek, Kutztown, Berks Co. (H. K. Deisher).
Lancaster, Lancaster Co. (J. B. Eshleman).
Susquehanna River, York Furnace, York Co. (W. Stone).

*Other localities represented in the Carnegie Museum:*

Stony Brook, Princeton, Mercer Co., New Jersey.
Tioughnioga River, Cortland, Cortland Co., New York (H. H. Smith).
Potomac River, Hancock, Washington Co., Maryland.
Wills Creek, Ellerslie, Allegany Co., Maryland.
South Branch Potomac River, Southbranch, Hampshire Co., West Virginia.
Shenandoah River, Harpers Ferry, Jefferson Co., West Virginia.
South Fork Shenandoah River, Elkton, Rockingham Co., Virginia.
South River, Waynesboro, Augusta Co., Virginia. (Headwaters of South Fork of Shenandoah.)
Catawba River, Bridgewater, Burke Co., North Carolina.

*Distribution and Ecology in Pennsylvania* (See fig. 19): From the published records it is seen that this species belongs to the Atlantic-drainage in Pennsylvania, and that it is rather evenly distributed over it, with the possible exception of the larger rivers. Specimens found by myself in the Delaware and lower Susquehanna are only few. In the smaller streams this species is more abundant, and locally common. This agrees well with the conditions seen in the western *A. marginata*, and with this *A. varicosa* also agrees in that it is distinctly a shell which

[134] Probably Eddington.

prefers strong currents and gravelly bottoms, thus being most frequently found in and near riffles. In the mountains it goes far up into the headwaters, and the most western locality is in Indiana Co., in a tributary of the West Branch of the Susquehanna (Cush Cushion Creek).

*General distribution. Type locality,* Schuylkill River, Philadelphia (Lamarck).

According to Simpson (1900), this species extends over the Atlantic-drainage from the lower St. Lawrence to South Carolina.

As has been stated above, the mutual relations of *A. varicosa* and *marginata* in central and western New York are doubtful, and specimens from New York are generally recorded under the name of *marginata,* although it is beyond doubt, according to our material, that *varicosa* is found in the upper Susquehanna-drainage in New York, and, according to the figures of DeKay in other parts of the state also.

The species has been reported from Maine (Lermond, 1909), New Hampshire (Call), Massachusetts (Gould-Binney, 1870), Rhode Island (Carpenter, 1890), and Connecticut (Linsley, 1845) but Johnson (1915, p. 27) erroneously calls the New England form *A. marginata.* Southward from Pennsylvania, *A. varicosa* is known from Red Clay Creek, Christiania Township, Newcastle Co., Delaware (Rhoads, 1904), and from the Potomac-drainage, in addition to the localities represented in the Carnegie Museum, from Sideling Creek, Allegany Co., Maryland, the Potomac River, Cherry Run, Morgan Co., West Virginia (Pilsbry, 1894).

Farther South, exact localities are missing, but Simpson's statement, that it extends to South Carolina, is substantiated by specimens collected by myself in the upper Catawba River in North Carolina. Among the latter are individuals which fully agree with the Pennsylvanian form, but this set is extremely variable in shape and especially in color.

*A. varicosa* of the Atlantic slope is the representant of the western *A. marginata,* and in its distribution apparently falls in line with several other Atlantic species, constituting a northern stock in the fauna of the Atlantic slope. This has been discussed elsewhere (Ortmann, 1913*a*, p. 363 & 370).

Walker (1913, p. 22) reports this species from Lake Erie; this, however, requires renewed attention, since the form from Lake Erie may belong to *A. marginata* (see above). I have never seen the lake-form, and thus I am unable to judge.

## Genus Strophitus Rafinesque (1820).

Ortmann, 1912, p. 299; Simpson, 1914, p. 344.

Type *Anodonta undulata* Say.

Two species of this genus are generally credited to Pennsylvania, but I have been able to find only one (*S. edentulus*), which is distributed all over the state both on the western and the eastern side of the mountains. The type-species possibly originally came from Pennsylvania, but being founded upon a very poor and immature specimen, has been largely misunderstood. Simpson (1900, p. 618; 1914, p. 345 & 349) admits the existence, on the Atlantic side, of "a small, thin form, . . . usually biangulate behind," but I have not been able to locate it.

Conner believes, that he has rediscovered the true *S. undulatus* of Say, and I have received from him specimens from the New Jersey side of the Delaware River (not far from the supposed type-locality of Say's specimen, on the Pennsylvania side of the river). However, I can see only a local race of the common *S. edentulus* in this, probably belonging to the tidewater region of the Delaware River, and connected by intergrades with the common form, wherever the latter goes into large and more quiet bodies of water. But since my material is entirely insufficient to solve the question, I shall mention here the two forms as *species*, thus avoiding the inconvenience of having to call the typical, common form by a varietal name (*S. undulatus edentulus*), and making the local race the main species (*S. undulatus*).

### Strophitus undulatus (Say) (1817).[135]

Simpson, 1914, p. 349 (but synonymy largely incorrect).

Plate XII, fig. 6.

*Records from Pennsylvania:*

Say does not give a type-locality for his *Anodonta undulata*, but his specimen probably came from near Philadelphia.

Lea (Obs. II, 1838, p. 54, and Obs. X, 1863, p. 450) repeatedly reports *A. undulata* Say from the Schuylkill River, near Philadelphia, and distinguishes it from *A. edentula*. The mouth of the Schuylkill, on the Delaware is just opposite the locality where Conner obtained his specimens.

All other records for this species are either very doubtful, whether they belong to the true *undulatus*, or are positively referable to *S. edentulus*.

(See Ortmann, 1909*b*, pp. 194 & 205.)

*Characters of the species:* Like *S. edentulus* in every particular, except that the beaks are slightly more inflated, elevated, and incurved. In consequence of this the shell appears higher anteriorly, and more tapering and pointed posteriorly.

[135] Not 1816.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. (♀) | 53 mm. | 33 mm. | 23 mm. |
| 2. | 52 " | 33 " | 24 " |

These are the two largest at hand.

*Soft parts:* I have seen only those of a sterile female, and find them identical with those of *S. edentulus*. *Glochidia* unknown.

*Breeding season:* Conner (1909, p. 112, as *Anodonta undulata*) found this form gravid in December and March, but not in April and May.

*Remarks:* For all the material I possess I am indebted to the kindness of Mr. C. H. Conner, who sent me eight specimens, all from the tide-waters of the Delaware River, near Newbold, Gloucester Co., New Jersey. These specimens show the differential characters given above. Mr. L. S. Frierson (*in litteris*) has called my attention to certain supposed differences in the hinge, but I am unable to see them. Moreover the shape of the shell is somewhat variable in the eight specimens at hand, and further I have specimens of the western *S. edentulus* (chiefly from quiet waters) which come very near to this form from the Delaware in the inflation of the beaks. Further I have certain large and old specimens of *S. edentulus*, where the inflation of the beaks is much greater than in any specimen from the Delaware. For instance a giant specimen from Cush Cushion Creek (abandoned reservoir) is very remarkable in this respect; but it was found among a large number of typical *edentulus* and cannot be anything else.

In the hinge there is the same variation as in *S. edentulus*. In some specimens vestiges of teeth are seen, in others they are almost entirely obliterated, and indicated only by slight thickenings and curves of the hinge-line. Mr. Frierson maintains that the tooth of the left valve (cardinal + interdental) is absent, and represented by an excavation. This does not hold good for all specimens before me, and, on the other hand, this is a condition, *very often* seen in *S. edentulus*.

I am very much inclined to think that this is only a local variety, or even only an ecological race, belonging to the tidewaters of the Delaware River, and localities with a similar environment. In the Delaware, just below Trenton, New Jersey (at Penns Manor, Bucks Co., Pennsylvania) I collected a specimen, which is rather small, and well agrees in outline with the specimens received from Mr. Conner, but the beaks are not inflated and elevated. Specimens from the Delaware River, Trenton, in the Philadelphia Academy, are typical *S. edentulus*. On the other hand, a specimen of *S. edentulus* from the Delaware-Raritan Canal, specimens from Conneaut Lake, Lake Erie, and Winona Lake, have the shells inflated more than usual, although the beaks are not so elevated as in the form from the lower Delaware, and thus the outline is more regularly elliptical, and

not ovate (higher anteriorly). Then again the ovate outline, with the anterior part of the shell high, and the posterior part more or less tapering, is also represented in typical *S. edentulus* with compressed shell.

The real *S. undulatus* therefore remains a disputed form.

Of course *S. undulatus*, as discussed here, is not fully identical with Simpson's *undulatus*, for Simpson included in this all small, thin, and generally distinctly biangulate shells (Simpson, 1900, p. 618, *footnote*). But these characters well fit *young* specimens of *S. edentulus*, while the specimens received from Conner are *not* biangulate behind, on account of the tapering posterior end.

*Locality represented in the Carnegie Museum:*

Delaware River, Newbold, Gloucester Co., New Jersey (C. H. Conner).

*Distribution* (See fig. 21): Frierson has sent me for examination a specimen from Warwick Pond, Warwick, Rhode Island, and another one from Orange Co., Virginia, but I have not been able to satisfy myself that they belong here, as was supposed, and that they are a species distinct from *S. edentulus*. Johnson (1915) keeps *S. undulatus* apart from *S. edentulus*, and gives for the former, a number of localities in New England, but I have no means of deciding what he understood by this species. No other records are known positively referring to this form.

### Strophitus edentulus (Say) (1829).

*Strophitus edentulus* (Say) Simpson, 1914, p. 345, and *Strophitus undulatus* Simpson (*pro parte*), *ibid.*, p. 349.

Plate XII, figs. 7, 8.

*Records from Pennsylvania:*

? Lea, Obs. X, 1863, p. 450 (Schuylkill River, Philadelphia).[136]

Bruckhart, 1869 (as *edentula*) (Lancaster Co.)

Hartman & Michener, 1874 (as *edentula*) (Brandywine Creek, Chester Co.)

Harn, 1891 (as *undulata*) (western Pennsylvania).

Schick, 1895 (as *undulata*) (Canal, 27th ward, Philadelphia).

Marshall, 1895 (as *edentula*) (Allegheny River, Warren Co.)

Rhoads, 1899 (as *edentula*) (Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co.; Beaver River, Wampum, Lawrence Co.)

Ortmann, 1909*b* (as *undulatus*), p. 194, 202, 207.

*Characters of the shell:* Shell of medium size, rather thin when young, moderately thick when old. Outline subelliptical to subovate, broadly rounded in front, more narrowly rounded behind, sometimes somewhat pointed or biangulate behind.

[136] Lea frequently refers to *A. undulata* as coming from the Schuylkill River. He distinguishes it from *A. edentula*, but we cannot tell which form he had in mind.

Lower margin convex or straight, sometimes slightly concave in the middle. Upper margin gently convex, forming a more or less distinct angle with the obliquely descending posterior margin. Beaks little prominent, situated in front of the middle. Beak-sculpture distinct, moderately heavy, consisting of about four concentric bars, placed obliquely with reference to the hinge line, rounded anteriorly, angular upon the posterior ridge. A few radiating lines anteriorly and posteriorly to the bars (See Marshall, 1890, fig. 12).

Shell generally gently convex or rather flat upon the sides, but occasionally more or less swollen or inflated. Posterior ridge indistinct and broadly rounded. Posterior slope somewhat compressed, and, when young, often elevated at the upper posterior angle.

Epidermis yellowish, greenish, brownish, or blackish, with more or less distinct greenish or blackish rays. Rays straight, narrow or wider, often quite obsolete. Posterior slope sometimes darker than the rest of the shell. Very old shells are mostly quite black all over. Concentric darker bands may be present.

Hinge much reduced. Lateral teeth entirely absent; pseudocardinals indicated only by slight swellings of the hinge-line; rarely can the single elements be made out. Generally, the hinge-line is only somewhat wavy under the beaks. Beak-cavity moderate. Dorsal muscle-scars in the beak-cavity. Anterior adductor-scars rather distinct, posterior ones less so. Nacre bluish white, toward the thick part of the shell pure white, or cream-color, and very often salmon-pinkish.

Male and female shells practically indistinguishable.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Cush Cushion Creek, Cat. No. 61.3627 (♂) | 106 mm. | 56 mm. | 43 mm. |
| 2. Grove City, Cat. No. 61.3278 (♀ gravid) | 102 " | 55 " | 39 " |
| 3. Tioga, Cat. No. 61.4154 (♀ gravid) | 81 " | 41 " | 32 " |
| 4. Milesburg, Cat. No. 61.4158 (♀ gravid) | 74 " | 42 " | 27 " |
| 5. Warren, Cat. No. 61.4164 (♂) | 66 " | 37 " | 22 " |
| 6. Darlington, Cat. No. 61.2945 (♂) | 44 " | 25 " | 16 " |

*Soft parts:* A poor figure was published by Lea (Obs. II, 1838, Pl. 15, fig. 47); a description was given by Ortmann, 1912, p. 299. *Glochidia* figured by Lea (Obs. VI, 1858, Pl. 5, fig. 5), and Surber (1912, Pl. 1, fig. 3). Surber's measurements are: $0.350 \times 0.285$, while mine (*l. c.*, p. 300) are: $0.36 \times 0.30$ mm.

*Breeding season:* Records for gravid females are most complete. They cover the time from July 11 to November 4, and from April 17 to May 22. It is a typically *bradytictic* form, with the interim between the breeding seasons falling, in our region, in the end of May, June, and the beginning of July. Surber (1912) gives a shorter interval, only in July.

*Remarks:* Although very variable in outline and color, this species is easily recognized by the elliptical shape, and the rudimentary condition of the hinge. If gravid females are at hand, the marsupial structure unmistakably indicates the genus. Only *Anodontoides ferussacianus* might be confounded with this species, but the shell of the latter is generally thinner, and the nacre is more bluish white, with very little pure white, and further the beak-sculpture is much finer.

Specimens with well-defined rays have been called *pavonia* Lea. The type locality of this is Little Beaver Creek in Ohio. I possess many specimens from this creek in Pennsylvania, and among them are many which correspond to *pavonia*, but they are connected by all possible intergrades with the normal *S. edentulus*.

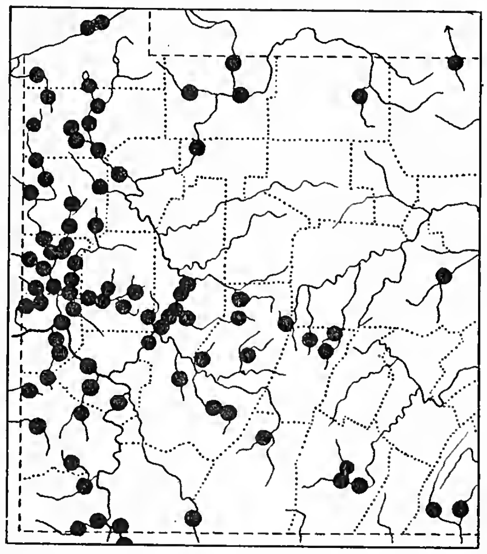

FIG. 20.

● *Strophitus edentulus* (western half of State of Pennsylvania).

Such brightly colored individuals may turn up anywhere, on the western as well as on the eastern side of the Alleghenies, and are always found associated with the normal form.[137]

There is little inclination to form local races, although under certain conditions and at certain localities the specimens look rather uniform. Thus in the mountain-streams on the western side of the mountains, there is a small, often more elongated race of *S. edentulus*, and the Allegheny River in general, does not produce very large, but rather heavy-shelled specimens. In the Beaver-drainage this species is much larger on the average. Strangely enough the largest specimens on record are from the Atlantic-drainage, in the headwaters of the West Branch of the

[137] Wilson & Clark (1912*a*, p. 48) believe that the better development of rays (in *pavonia*) is correlated with the clearness of the water, and I think that this is right.

Susquehanna (Cush Cushion Creek); but these came from an old, abandoned reservoir, with a muddy bottom and rich vegetation.

Specimens from Conneaut Creek, tributary to Lake Erie, do not differ from the normal type. However, in Lake Erie proper a peculiar form is found. I myself did not find many specimens, but I have received additional ones from C. Goodrich, and all these represent a dwarfed race (largest at hand: L. 51 mm.,

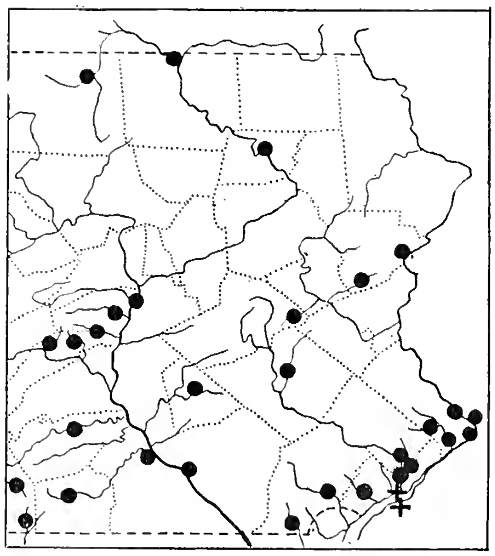

FIG. 21.

● *Strophitus edentulus* (eastern half).
+ *Strophitus undulatus.*

H. 28 mm., D. 20 mm.), of a rather regular, subelliptical and elongate outline. I do not, however, think it advisable to distinguish this race by a varietal name.

*Localities in Pennsylvania, represented in the Carnegie Museum:*

*Small tributaries of the Ohio:*

Buffalo Creek, Acheson, Washington Co.
Cross Creek, Avella, Washington Co.
Little Beaver Creek, Cannelton (H. H. Smith), Darlington, New Galilee, Beaver Co.; Enon Valley, Lawrence Co.
Raccoon Creek, Raccoon Township and New Sheffield, Beaver Co.; Bavington, Washington Co.
Chartiers Creek, Carnegie, Allegheny Co. (D. A. Atkinson & J. L. Graf).
Little Chartiers Creek, Morganza, Washington Co.

*Beaver-drainage:*

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Connoquenessing Creek, Ellwood City, Lawrence Co. (G. H. Clapp & H. H. Smith); Celia, Beaver Co.; Zelienople, Butler Co.; Harmony, Butler Co. (R. G. Pflaum).
Slipperyrock Creek, Wurtemberg and Rose Point, Lawrence Co.

Wolf Creek, Grove City, Mercer Co.
Brush Creek, Celia, Beaver Co.
Little Connoquenessing Creek, Harmony, Butler Co.
Thorn Creek, McBride, Butler Co.
Bonnie Brook, East Butler, Butler Co.
Mahoning River, Mahoningtown, Coverts, and Edinburg, Lawrence Co.
Neshannock Creek, Eastbrook, and Volant, Lawrence Co.; Leesburg, Mercer Co.
Otter Creek, Mercer, Mercer Co.
Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Shenango and Jamestown, Mercer Co.; Linnesville, Crawford Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.

*Allegheny-drainage:*

Allegheny River, Natrona, Allegheny Co.; Aladdin, Godfrey, Kelly, Mosgrove, and Templeton, Armstrong Co.; Hickory, Forest Co.; Warren, Warren Co.
Buffalo Creek, Harbison, Butler Co.
Loyalhanna River, Idlepark and Ligonier, Westmoreland Co.
Beaver Run, Delmont, Westmoreland Co.
Blacklegs Creek, Saltsburg, Indiana Co.
Yellow Creek, Homer, Indiana Co.
Quemahoning Creek, Stanton's Mill, Somerset Co.
Crooked Creek, Rosston, Armstrong Co.; Creekside, Indiana Co.
Little Mahoning Creek, Goodville, Indiana Co.
Sandy Creek, Sandylake, Mercer Co.
French Creek, Utica, Venango Co.; Cochranton, Meadville, and Cambridge Springs, Crawford Co.
Conneaut Outlet, Conneautlake, Crawford Co.
Conneaut Lake, Crawford Co.
Conneauttee Creek, Edinboro, Erie Co.
Brokenstraw Creek, Garland, Warren Co.
Connewango Creek, Russell, Warren Co.
Potato Creek, Smethport, McKean Co. (P. E. Nordgren).

*Monongahela-drainage:*

Monongahela River, Elizabeth, Allegheny Co. (D. A. Atkinson).
Youghiogheny River, Confluence, Somerset Co.
Tenmile Creek, Clarksville, Greene Co.; Amity, Washington Co.
South Fork Tenmile Creek, Waynesburg, Greene Co.
Dunkard Creek, Wiley and Mount Morris, Greene Co.
Cheat River, Cheat Haven, Fayette Co.

*Lake Erie-drainage:*

Conneaut Creek, West Springfield, Erie Co.; Springboro, Crawford Co.
Lake Erie, Presque Isle Bay, Erie, Erie Co.

*Genesee River-drainage:*

Genesee River, Genesee, Potter Co.

*Delaware-drainage:*

Delaware River, Penns Manor and Yardley, Bucks Co.; Shawnee, Monroe Co.
Schuylkill River, Manayunk, Philadelphia Co.
Schuylkill Canal, Manayunk, Philadelphia Co.
Wissahickon Creek, Roxboro, Philadelphia Co.
Little Neshaminy Creek, Grenoble, Bucks Co.
Princess Creek, Kunkletown, Monroe Co.
Lizard Creek, Mantz, Schuylkill Co.

*Susquehanna-drainage:*

Susquehanna River, Selinsgrove, Snyder Co.
Conewago Creek, York Haven, York Co.; Table Rock, Adams Co.
Conodoguinet Creek, Carlisle, Cumberland Co.
Cocolamus Creek, Cocolamus, Juniata Co. (D. A. Atkinson).
Lost Creek, Mifflintown, Juniata Co. (D. A. Atkinson).
Raystown Branch Juniata River, Everett and Mount Dallas, Bedford Co.
Dunning Creek, Bedford, Bedford Co. (J. F. L. Raschen).
West Branch Mahantango Creek, Richfield, Juniata Co.
Middle Creek, Freeburg, Snyder Co. (D. A. Atkinson).
Bald Eagle Creek, Milesburg, Center Co.
Beaver Dam Creek, Flinton, Cambria Co. (D. A. Atkinson).
Swartz Run, Ashville, Cambria Co.
Chest Creek, Patton, Cambria Co.
Cush Cushion Creek, Green Township, Indiana Co.
North Branch Susquehanna River, Tunkhannock, Wyoming Co.
Chemung River, South Waverly, Bradford Co.
Millrace of Crooked Creek, Tioga, Tioga Co.

*Potomac-drainage:*

East Branch Little Antietam Creek, Waynesboro, Franklin Co.
Conococheague Creek, Greencastle and Scotland, Franklin Co.
West Branch Conococheague Creek, Mercersburg Junction, Franklin Co.

*Pennsylvanian localities represented in the Philadelphia Academy of Natural Sciences:*

Big Elk Creek, Westgrove, Chester Co. (C. H. Conner).[138]
Chester Creek, Delaware Co.
Maiden Creek, Berks Co.
Big Neshaminy Creek, "Edderton" (probably Eddington), Bucks Co. (H. W. Fowler).
Columbia, Lancaster Co. (J. B. Eshleman).
Little Swatara Creek, Jonestown, Lebanon Co. (C. H. Conner).

*Additional locality in New Jersey:*

Delaware River, Trenton, Mercer Co., New Jersey (H. Hamilton).

[138] Not exact, either creek or town given incorrectly.

*Other localities represented in the Carnegie Museum:*

*Lake-drainage:*

Seneca Co., New York (Smith collection).

Conestogo River, Conestogo, Waterloo Co., Ontario, Canada (Miss Maria Jentsch).

Lake Erie, Port Dover, Norfolk Co., Ontario, Canada; Vermilion, Erie Co., Ohio; La Plaisance Bay Monroe Co., Michigan (C. Goodrich).

Creek at North Fairfield, Huron Co., Ohio (O. E. Jennings).

Sandusky River, Upper Sandusky, Wyandot Co., Ohio (C. Goodrich).

Swan Creek and Ten Mile Creek, Toledo, Lucas Co., Ohio (C. Goodrich).

St. Marys River, Rockford, Mercer Co., Ohio (C. Goodrich).

Beaver Creek, Williams Co., Ohio (C. Goodrich).

Maumee River, Fort Wayne, Allen Co., Indiana (C. Goodrich).

Otter Creek, Monroe Co., Michigan (C. Goodrich).

Raisin River, Adrian and Tecumseh, Lenawee Co., Michigan (C. Goodrich).

*Drainage of Red River of the North:*

Sheyenne River, Argusville, Cass Co., North Dakota (S. M. Edwards).

*Ohio-drainage:*

West Branch Nimishillen Creek, Canton, Stark Co., Ohio.

Tuscarawas River, Ohio (Holland collection).

Scioto River, Columbus, Franklin Co., Ohio (Smith collection).

Wabash River, St. Henry, Mercer Co., Ohio (C. Goodrich).

Winona Lake, Kosciusko Co., Indiana (E. B. Williamson).

Cheat River, Jaco and Mount Chateau, Monongalia Co., West Virginia.

Tygart River, Elkins, Randolph Co., West Virginia.

French Creek, Hampton, Upshur Co., West Virginia.

West Fork River, Lynch Mines, Harrison Co.; Weston, Lewis Co., West Virginia.

Little Kanawha River, Burnsville, Braxton Co., West Virginia.

North Fork Hughes River, Cornwallis, Ritchie Co., West Virginia.

Elk River, Shelton and Clay, Clay Co.; Gassaway and Sutton, Braxton Co., West Virginia.

Coal River, Sproul, Kanawha Co., West Virginia.

Licking River, Farmer, Rowan Co., Kentucky.

*Cumberland- and Tennessee-drainages:*

Cumberland River, Burnside, Pulaski Co., Kentucky (B. Walker, donor, soft parts only).

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).

Elk River, Estill Springs, Franklin Co., Tennessee (H. H. Smith).

Tennessee River, Concord, Knox Co., Tennessee.

French Broad River, Boyd Creek, Sevier Co., Tennessee.

Holston River, McMillan and Mascot, Knox Co.; Hodges, Jefferson Co.; Turley Mill, Noeton, and Holston Station, Grainger Co., Tennessee.

South Fork Holston River, Pactolus and Bluff City, Sullivan Co., Tennessee.

North Fork Holston River, Rotherwood, Hawkins Co., Tennessee; Hilton, Scott Co., Virginia; Saltville, Smyth Co., Virginia.

Clinch River, Solway, Knox Co.; Edgemoor and Clinton, Anderson Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; St. Paul, Wise Co., Cleveland, Russell Co., Raven, Richland, and Cedar Bluff, Tazewell Co., Virginia.

Powell River, Combs, Claiborne Co., Tennessee; Dryden, Lee Co., Virginia.
South Fork Powell River, Big Stone Gap, Wise Co., Virginia.

*Mississippi River and westward:*

Mississippi River, Muscatine, Muscatine Co., Iowa (Hartman collection).
Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).
Hinkston Creek, Columbia, Boone Co., Missouri (D. K. Greger).
James River, Galena, Stone Co., Missouri (A. A. Hinkley).
White River, Hollister, Taney Co., Missouri (W. I. Utterback); Cotter and Norfolk, Baxter Co., Arkansas (A. A. Hinkley).
Black River, Black Rock, Lawrence Co., Arkansas (H. E. Wheeler).
Saline River, Benton, Saline Co., Arkansas (H. E. Wheeler).
Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).
Lawrence, Douglas Co., Kansas (R. L. Moodie).
Fourteen Mile Creek, Fort Gibson, Muskogee Co., Oklahoma (F. B. Isely).

*Atlantic-drainage:*

Delaware-Raritan Canal, Princeton, Mercer Co., New Jersey.
Potomac River, Hancock, Washington Co., Maryland.
South Branch Potomac River, Romney, Hampshire Co., West Virginia.
North Fork Shenandoah River, Broadway, Rockingham Co., Virginia.
South Fork Shenandoah River, Elkton, Rockingham Co., Virginia.
South River, Waynesboro, Augusta Co., Virginia.
Rappahannock River, Remington, Fauquier Co., Virginia.
Rapidan River, Rapidan, Culpeper Co., Virginia.
Mountain Run, Culpeper, Culpeper Co., Virginia.
North River, Buena Vista and Lexington, Rockbridge Co., Virginia.
Calf Pasture River, Goshen, Rockbridge Co., Virginia.
Roanoke River, Salem, Roanoke Co., Virginia.
Mason Creek, Salem, Roanoke Co., Virginia.

*Distribution and Ecology in Pennsylvania* (See figs. 20 & 21): This is the only species of Naiad whose range covers the whole of the state of Pennsylvania, the divide of the Allegheny Mountains having no influence whatever upon it. The forms found on either side of the divide do not differ at all, and go far up into the headwaters, so that there is practical continuity of distribution across the divide. There is no doubt that this distribution is to be accounted for by an actual crossing over from the western to the eastern slope, and probably this has been effected by stream piracy. This has been discussed elsewhere (Ortmann, 1913*a*, pp. 367–369).

*Strophitus edentulus* also is extremely common all over the state, although it is distinctly averse to large rivers. Rhoads reports it from the Ohio below Pittsburgh, but I have never found it there. Above Pittsburgh it appears in the Allegheny, but is decidedly scarce in Allegheny and Armstrong Cos., and the specimens

are rather small on the average. Farther up, and in the tributaries, it becomes more and more abundant, and in all small creeks it is a common shell.

The fact is remarkable, that *S. edentulus* is the only Naiad present in the upper Youghiogheny. There is no other stream in Pennsylvania, which offers a parallel case, but such are found in several mountain streams in West Virginia. This has been discussed elsewhere (Ortmann, 1913*a*, pp. 303, 305, 308; 357, 367 *et seq.*).

Likewise on the Atlantic slope this species is scarce or missing in the large rivers. This is most evident in the lower Susquehanna. It is present in the Delaware near and above Trenton, New Jersey, but does not seem to be abundant. It may be that in the estuary of the Delaware *S. undulatus* takes its place.

We may therefore call *S. edentulus* a form characteristic of smaller streams. Baker (1898*a*, p. 68) says indeed that it is found in the larger lakes and rivers on muddy bottoms, while Scammon (1906, p. 323) reports it to prefer mud and quiet water, and to be most abundant in smaller streams (in Kansas). Its absence in the larger rivers in Pennsylvania may be connected with its aversion to rough bottom and strong currents. Even in the small streams it avoids riffles, but delights in quiet and protected nooks, pools, and eddies, where there is a moderate and rather uniform current, and a deposit of fine gravel, sand, or mud. It is often found in the *Dianthera*-patches.

On the other hand this species goes into canals and lakes. Altogether, it lives under a great variety of environmental conditions, and thus it is not astonishing that it is so widely distributed.

*General distribution: Type locality,* Wabash River (Say).

According to Simpson (1900) *S. edentulus* ranges over the "entire Mississippi-drainage; the St. Lawrence system and south in streams draining into the Atlantic to North Carolina; north in the British possessions to Lake Winnipeg; southwest to central Texas." (An Alabaman locality has also been recorded.)

This is substantially correct, and this is possibly the widest range occupied by any species of Naiad in North America. Its occurrence in Canada in the lower St. Lawrence-drainage, as well as in the west, is well-established (Whiteaves, 1863; Bell, 1859; Call, 1885; Dawson, 1875; Hanham, 1899; Christy, 1855; see also our records from Ontario and North Dakota). Its presence on the Atlantic slope from Maine (Lermond, 1909) southward is well known, and substantiated by our records as far South as the Roanoke system in Virginia. It is said to go to North Carolina (Simpson), but here the southern boundary is obscurely known.

The center of radiation is apparently located in the Mississippi system (See

Ortmann, 1913*a*, p. 367 *et seq.*). It is found everywhere in the drainage of the Ohio and in that of the upper Mississippi. There are sections, where records are scarce or missing, as for instance in Kentucky, and its absence in the upper Kanawha system in West Virginia and Virginia should be noted (See Ortmann, 1913, pp. 308 and 367). It seems to be rare in the Cumberland (Wilson & Clark, 1914), but in the upper Tennessee system in Tennessee and Virginia it is common.

In a westerly and southwesterly direction it goes across the Mississippi, and has been found as far west as eastern Nebraska (Tryon, 1868); in Kansas, as far as Saline Co., in the Kansas-drainage, and Reno County, in the southern drainage (Scammon, 1906). From Arkansas it has been reported by Call (1895) and Meek & Clark (1912), and it is represented from the Ozark streams, the Saline and Ouachita Rivers in the Carnegie Museum (previously reported from Ouachita by Vanatta, 1910, and Wheeler, 1918). It is also present in Oklahoma (Carnegie Museum). Frierson (1899) reports it from a tributary of Sabine River in De Soto Parish, Louisiana, and according to Simpson it goes to central Texas (Vaughan, 1893, does not mention it from northwestern Louisiana, and Singley, 1893, does not mention it from Texas).

Records from the southern Atlantic and Gulf states are lacking, though Simpson cites Tyner, Tuscaloosa Co., Alabama; and a number of allied forms, separated as species, are credited to Georgia, Alabama, and Mississippi. I cannot judge of these; but I may mention, that specimens from the Alabama-drainage in the Carnegie Museum, partly collected by H. H. Smith, partly by myself, seem to differ, and to represent possibly two other species: *S. connasaugaënsis* (Lea) (= *alabamensis* Lea = *gesneri* Lea), and *S. spillmani* (Lea). Both have the pseudocardinal teeth better developed than *S. edentulus*.

## Subfamily LAMPSILINÆ (v. Ihering, 1901) Ortmann (1910).[139]

Ortmann, 1910, p. 118; 1911, p. 337; 1912, p. 300.

### Key to the Genera of the Lampsilinæ.

$a_1$. Marsupium not kidney-shaped. Ovisacs subcylindrical or very slightly compressed. Placentæ generally very solid. Inner edge of mantle in front of branchial opening, not distinctly differentiated. Shell rounded, ovate, subelliptical, sometimes with sculpture upon the disk. Male and female shells practically alike.

- $b_1$. Marsupium occupying the whole of the edge of the outer gill, folded. Placentæ club-shaped, short. Shell subelliptical, smooth.......................................... *Ellipsaria.*
- $b_2$. Marsupium occupying only a part of the outer gill. Placentæ subcylindrical, elongated or very long. Shell more or less rounded, generally with tubercles.

[139] V. Ihering first coined this subfamily-name, but places some of the genera belonging here in his subfamily *Quadrulinæ*.

$c_1$. Placentæ moderately long, slightly curved. Marsupium just behind the middle of the gill. Outside of shell with a few large knobs. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Obliquaria.*

$c_2$. Placentæ very long, spirally coiled up. Marsupium in, or slightly in front of, the middle of the gill. Outside of shell with numerous small tubercles. . . . . . . . . . . . . . . . . . . *Cyprogenia.*

$a_2$. Marsupium kidney-shaped. Ovisacs lanceolate, dilated and compressed. Placentæ not very solid. Inner edge of mantle in front of branchial opening, more or less differentiated. Shell rounded, elliptical, or elongate, without sculpture on the disk.

$b_1$. Inner edge of mantle, in front of branchial opening, slightly lamellate and crenulated, but without papillæ or flaps. Male and female shell differing only slightly in shape, or hardly at all.

$c_1$. Shell rounded, ovate, or subelliptical. Glochidia of normal size and shape, subovate.

$d_1$. Shell rounded or short-ovate. Epidermis brownish, rarely greenish, with indistinct rays. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Obovaria.*

$d_2$. Shell ovate or subelliptical, elongate. Epidermis greenish or yellowish, with more or less distinct rays. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Actinonaias.*

$c_2$. Shell ovate, triangular, or subelliptical. Glochidia either of abnormal size or shape.

$d_1$. Shell subovate or subtriangular, with a strong posterior ridge.

$e_1$. Glochidia of normal shape (subovate), but of abnormally small size. Shell subovate or elongate. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Amygdalonaias.*

$e_2$. Glochidia spatulate, with gaping margins, very large. Shell subtriangular. *Plagiola.*

$d_2$. Shell subovate or subelliptical, generally compressed and winged at the upper posterior part, without distinct posterior ridge.

$e_1$. Glochidia of normal shape, but of abnormally small size. Shell rather thin. *Paraptera.*

$e_2$. Glochidia celt-shaped, with two spines on each valve. Shell thicker. . . . . *Proptera.*

$b_2$. Inner edge of mantle, in front of branchial opening, with papillæ or flaps. Male and female shell distinctly, and often greatly, different in shape.

$c_1$. Inner edge of mantle parallel with and close to the outer edge. Glochidia subovate or subelliptical.

$d_1$. Inner edge of mantle with papillæ.

$e_1$. Papillæ few, represented chiefly by one large caruncle. Shell very small. Beak-sculpture concentric. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Toxolasma.*

$e_2$. Papillæ more numerous. Shell small, medium, or large. Beak-sculpture double-looped. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Eurynia.*

$d_2$. Inner edge of mantle forming a ribbon-like flap, projecting at the anterior end. Shell large. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Lampsilis.*

$c_2$. Inner edge of mantle, in front of branchial opening, more or less remote from outer edge in the female. Glochidia subcircular. Shell rather small, of peculiar and various shapes, chiefly in the female. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Truncilla.*

## Genus Ellipsaria Rafinesque (1820).

*Ptychobrancus* (Simpson) Ortmann, 1912, p. 305; Simpson, 1914, p. 332; *Ellipsaria* Frierson, 1914*a*, p. 7.

Type *Obliquaria fasciolaris* Rafinesque.

Only the type-species known from Pennsylvania.

### Ellipsaria fasciolaris (Rafinesque) (1820).

*Ptychobranchus phaseolus* (Hildreth) Simpson, 1941, p. 333; *Ellipsaria fasciolaris* (Rafinesque) Frierson, 1914*a*, p. 7; *Ptychobranchus fasciolaris* (Rafinesque) Vanatta, 1915, p. 554.

Plate XIII, figs. 1, 2, 3.

*Records from Pennsylvania:*

Harn, 1891 (western Pennsylvania).
Marshall, 1895 (Allegheny River, Warren Co.).
Rhoads, 1899 (Beaver River, Wampum, Lawrence Co.).
Ortmann, 1909*b*, pp. 194 and 202.

*Characters of the shell:* Shell of medium size, but comparatively thick and heavy. Outline subelliptical, more or less elongated; when old, often humped (subtriangular), and drawn out at the lower posterior end. Upper and lower margins more or less convex, posterior end narrower than anterior, rounded or bluntly pointed. In old specimens the lower margin may be straight, and it sometimes becomes even concave in the middle. Beaks in front of the middle, very little elevated above the hinge-line. Beak-sculpture rudimentary, consisting of two or three faint ridges which are interrupted, and have thus a tendency to appear double-looped.

Valves moderately and rather evenly convex, slightly more flattened on the sides. Posterior ridge practically absent, or indicated only by a stronger convexity of the valves. No sculpture upon the surface.

Epidermis yellowish to light brown, rarely dark brown; generally ornamented with dark green rays, which are most distinct in young specimens. The rays are capillary and interrupted, but are generally grouped together in bundles, and very often fused together, so as to form more or less squarish, green spots. There is great variability in the size and the arrangement of these spots, and in very rare cases they are entirely missing. Old shells have the rays less distinct, and the epidermis becomes more or less uniformly brown. Concentric bands of color are absent, or the color is only slightly darker along the growth-lines.

Hinge well-developed. Pseudocardinals stumpy, heavy, but not much elevated. Laterals thick and heavy, club-shaped, thicker posteriorly. Interdentum narrow. Beak-cavity shallow. Dorsal muscle-scars in the beak-cavity. Adductor-scars distinct and rather deep.

Nacre white, generally without any color, except in very young specimens, where there may be a faint pink blush.

Externally there are no sexual differences in the shell, except that the males

are slightly more compressed than the females. It is indeed often impossible to ascertain the sex by this character. Internally the female shell is marked by a wide, oblique groove, running from the beak-cavity toward the posterior end, which corresponds to the marsupium (Pl. XIII, fig. 2). The marsupial folds are also generally marked as depressions in this groove. These depressions are best marked in old specimens and are indistinct or absent in young ones.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Cannelton, Cat. No. 61.1166 (♀) | 132 mm. | 72 mm. | 43 mm. |
| 2. Harbor Bridge, Cat. No. 61.3601 (gravid ♀) | 125 " | 62 " | 40 " |
| 3. New Sheffield, Cat. No. 61.3275 (♂) | 109 " | 65 " | 32 " |
| 4. Shenango, Cat. No. 61.4134 (♂) | 87 " | 47 " | 28 " |
| 5. Rose Point, Cat. No. 61.3116 (♂) | 73 " | 42 " | 22 " |
| 6. Waterford, Cat. No. 61.4133 (♀ gravid) | 66 " | 36 " | 21 " |

Our largest specimens (Nos. 1 and 2) exceed the maximum size (110 mm.) recorded by Scammon (1906, p. 320).

*Soft parts* (See Ortmann, 1912, p. 306). They have been figured by Lea (Obs. VII, 1860, Pl. 29, fig. 101) and Lefevre & Curtis (1910, Pl. 1, fig. 1, and 1912, Pl. 6, fig. 1). *Glochidia:* Lea (Obs. VI, 1858, Pl. 5, fig. 12) poor; Ortmann (1911*b*, Pl. 89, fig. 14).

*Breeding season:* The following records for gravid females are at hand: Aug. 4, 1908 (eggs); Aug. 29, 1910; Sept. 1, 1908 (young glochidia); Sept. 2, 1907; Sept. 6, 1908; Sept. 7, 1908; Sept. 11, 1913; Sept. 13, 1909; Sept. 13, 1915; Sept. 13, 1917; Sept. 15, 1908; Sept. 15, 1915; Sept. 18, 1917; Sept. 21, 1907; Sept. 21, 1908; Sept. 27, 1909; Oct. 4, 1910; Oct. 15, 1907; Oct. 15, 1908; Oct. 19, 1908; Oct. 21, 1908; Oct. 23, 1907. Then again: June 23, 1910 (discharging); Aug. 31, 1906 (discharging).

The beginning of the season is well established as being the month of August, and the discharge takes place in spring and early summer. Probably the (single) discharging individual observed on Aug. 31 was exceptionally belated. The species is positively *bradytictic*.

*Remarks:* This is an easily recognized species. The subelliptical outline, light brown epidermis, color-markings, and heavy hinge are unmistakable. However specimens of dark color and without rays might be mistaken for *Elliptio dilatatus*, but the interior of the shell generally determines the question.

There is a good deal of variation in shape and color. The humped shape of old shells does not develop in many cases, although on the other hand it may be already in evidence in comparatively small individuals. Specimens from the mountain-streams (Cheat, Loyalhanna, Quemahoning) are much smaller than

usual; and thus there is in the mountains a tendency toward the formation of a small race. Lake Erie possesses a somewhat peculiar form (Plate XIII, fig. 3), in which the specimens remain small; the dimensions of the largest at hand, a gravid female, being: L. 72, H. 40, D. 24 mm., and they assume the humped shape when comparatively small. Further, the growth-lines are more crowded, and more regular, but not very distinct (not marked by color). Young shells of the

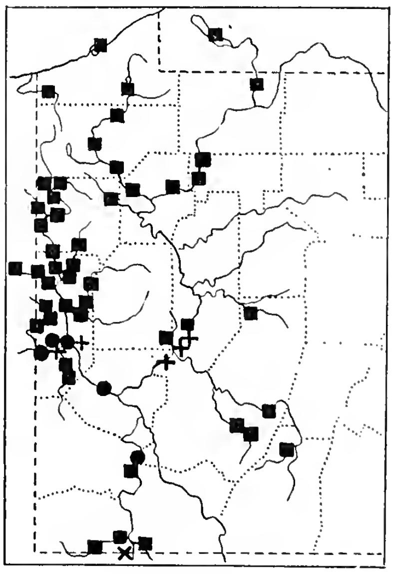

FIG. 22.

■ *Ellipsaria fasciolaris.*
● *Obliquaria reflexa.*
+ *Cyprogenia stegaria.*
× *Do.* (Indian garbage heap).

form from Lake Erie are indistinguishable from specimens of the same size from the Ohio-drainage. I do not think it advisable to distinguish the lake-form by a varietal name, but the tendency to develope a local race is clearly indicated in this case.

Specimens from Conneaut Creek (tributary to Lake Erie) are entirely normal.

It should be mentioned that the form from Chautauqua Lake in New York inclines toward that of Lake Erie in the more crowded growth-lines, and the average size, a fact which is apparently due to the parallel influence of the environment.

*Localities in Pennsylvania, represented in the Carnegie Museum:*

*Small tributaries of Ohio:*

Little Beaver Creek, Cannelton (Miss Vera White & H. H. Smith) and New Galilee, Beaver Co.; Enon Valley, Lawrence Co.

Raccoon Creek, New Sheffield, Beaver Co.

*Beaver-drainage:*

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Connoquenessing Creek, Ellwood City, Lawrence Co. (G. H. Clapp & H. H. Smith).
Slipperyrock Creek, Wurtemberg and Rose Point, Lawrence Co.
Mahoning River, Mahoningtown, Coverts, Edinburg, and Hillsville, Lawrence Co.
Neshannock Creek, Eastbrook and Volant, Lawrence Co.; Leesburg, Mercer Co.
Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Sharpsville, Clarksville, Shenango and Jamestown, Mercer Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Little Shenango River, Greenville, Mercer Co.

*Allegheny-drainage:*

Allegheny River, Kelly, Armstrong Co.; Walnut Bend, Venango Co.; Tionesta and Hickory, Forest Co.
Buffalo Creek, Harbison, Butler Co.
Loyalhanna River, Idlepark and Ligonier, Westmoreland Co.[140]
Quemahoning Creek, Stantons Mill, Somerset Co.
Little Mahoning Creek, Goodville, Indiana Co.
Sandy Creek, Sandylake, Mercer Co.
French Creek, Utica, Venango Co.; Cochranton, Meadville, and Cambridge Springs, Crawford Co.
Leboeuf Creek, Waterford, Erie Co.
Connewango Creek, Russell, Warren Co.

*Monongahela-drainage:*

Monongahela River, Charleroi, Washington Co. (G. A. Ehrmann).
Dunkard Creek, Wiley and Mount Morris, Greene Co.
Cheat River, Cheat Haven, Fayette Co.

*Lake Erie-drainage:*

Conneaut Creek, West Springfield, Erie Co.
Lake Erie, Presque Isle Bay, Erie, Erie Co.

### *Other localities represented in the Carnegie Museum:*

*Lake-drainage:*

Lake Erie, Vermilion, Erie Co., Ohio; La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).
Grand River, Cayuga, Haldimand Co., Ontario, Canada (C. Goodrich).
Sandusky River, Fremont, Sandusky Co., Ohio (C. Goodrich).
Maumee River, Roche de Boeuf Rapids and Waterville, Lucas Co.; Otsego Rapids, Wood Co.; Defiance, Defiance Co., Ohio (C. Goodrich).
Raisin River, Monroe and Grape P. O., Monroe Co., Michigan (C. Goodrich).

*Ohio-drainage:*

Lake Chautauqua, Bemus Point (D. R. Sumstine), Griffith Landing (Miss B. Ortmann), and Celoron (P. E. Nordgren), Chautauqua Co., New York.
Tuscarawas River, Ohio (Holland collection).
Ohio River, Toronto, Jefferson Co.; Portsmouth, Scioto Co., Ohio.

[140] Dead shells were seen, but not taken, in the Conemaugh River at New Florence, Westmoreland Co.

Cheat River, Jaco and Mont Chateau, Monongalia Co., West Virginia.

West Fork River, Lynch Mines, Harrison Co.; West Milford, Harrison Co. (W. F. Graham); Lightburn, Lewis Co., West Virginia.

Little Kanawha River, Grantsville, Calhoun Co. (W. F. Graham); Burnsville, Braxton Co., West Virginia.

Elk River, Shelton and Clay, Clay Co.; Gassaway and Sutton, Braxton Co., West Virginia.

Licking River, Farmer, Rowan Co., Kentucky.

*Tennessee-drainage:*

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith); Knox Co., Tennessee (Smith collection).

Bear Creek, Burleson, Franklin Co., Alabama (H. H. Smith).

Elk River, Estill Springs, Franklin Co., Tennessee (H. H. Smith).

Paint Rock River, Paint Rock and Trenton, Jackson Co., Alabama (H. H. Smith).

South Chickamauga Creek, Ringgold, Catoosa Co., Georgia.

French Broad River, Boyd Creek, Sevier Co., Tennessee.

Holston River, Mascot, Knox Co.; Turley Mill, Noeton, and Holston Station, Grainger Co.; Austin Mill, Hawkins Co., Tennessee.

South Fork Holston River, Pactolus, Bluff City, and Emmett, Sullivan Co., Tennessee.

North Fork Holston River, Rotherwood, Hawkins Co., Tennessee; Hilton, Scott Co., and Mendota, Washington Co., Virginia.

Clinch River, Edgemoor, Clinton, and Offutt, Anderson Co.; Black Fox Ford, Union Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Speers Ferry and Clinchport, Scott Co., Virginia; St. Paul, Wise Co.; Fink and Cleveland, Russell Co., Virginia.

Emory River, Harriman, Roane Co., Tennessee.

Powell River, Combs, Claiborne Co., Tennessee.

*Distribution and Ecology in Pennsylvania* (See fig. 22): In Pennsylvania this is preëminently a species of smaller rivers and creeks. It is very rare in the Allegheny below Oil City, and has not been found in the Ohio. In the Monongahela it must also have been rare. But in the tributaries it is abundant, with the exception of the smallest headwaters. It goes far eastwards toward the divide in Indiana, Westmoreland, and Somerset Counties. It is also found in Cheat River and the upper Monongahela in West Virginia.

Furthermore it occurs in Lake Erie and its tributary, Conneaut Creek, and *may* have crossed into the lake-drainage from the upper Beaver-drainage.

That it avoids large rivers holds good further down the Ohio, although it is not entirely absent there. Its ecological preferences are distinctly for riffles and strongly flowing water, with finer or coarser, but firmly packed gravel. Very frequently it is found along the edges of *Dianthera*-patches, always in a lively current. In Lake Erie it is chiefly found on the North shore of Presque Isle Bay, in two or three feet of water, on sandy or slightly gravelly bottom, exposed to the moderate surf of the bay, but it is not abundant there. Scammon (1906) says that this species prefers (in Kansas) the smaller streams.

*General distribution: Type locality,* Kentucky River (Vanatta) (Rafinesque gives as habitat the Ohio, Wabash, and Kentucky Rivers).

Simpson (1900) gives its distribution as follows: "Ohio, Tennessee, and Cumberland river systems; peninsula of Michigan; Kansas; Arkansas; Indian Territory; Louisiana." This possibly requires modification with regard to the southwestern range. The most noteworthy feature in its distribution is its absence in the upper Mississippi-drainage. Numerous localities are known from all over Ohio (Sterki, 1907*a*). In Indiana (Call, 1896*a* & 1900) it is found practically all over the state, both in the Ohio and Erie drainages, but it is absent in the Lake Michigan-drainage. As our localities show, it occurs also in West Virginia, and is very abundant in the upper Tennessee region. Wilson & Clark (1914) report it from the upper Cumberland River. In very strong contrast to the foregoing is its scarcity in Illinois. In the latter state it is known only in the southern parts and in the Wabash River (Baker, 1906). Simpson extends the range in a southwesterly direction across the Mississippi. (See also Call, 1895, for Arkansas, and Scammon, 1906, for Kansas.) However, the specimens I have seen from Missouri, Arkansas, and Oklahoma are not typical *E. fasciolaris*, and represent, as has been recognized by Utterback (1916, p. 128) and hinted at by Wheeler (1918, p. 120), a different species. This species is distinct in the rays, which are fine and capillary, and never form blotches.[141]

In a northeasterly direction this species has crossed over into the lake-drainage, going probably by way of the Maumee-route. It has spread over practically the whole lower peninsula of Michigan (as far north as Cheboygan Co.) (See Walker, 1892 & 1898). In Lake Erie it has reached New York at Buffalo (Marshall, 1895). It is clear that the other locality in New York, Chautauqua Lake, was reached from the upper Allegheny.

Two records from Wisconsin and Minnesota are undoubtedly in error and already have been dropped by Simpson.

### Genus Obliquaria Rafinesque (1820).

Ortmann, 1912, p. 309; Simpson, 1914, p. 329.

Type *Obliquaria reflexa* Rafinesque.

A monotypic genus.

[141] This species should be called *Ellipsaria occidentalis* (Conrad) (1836) (Currant River, Arkansas), the synonym of which is *Ptychobranchus clintonensis* Simpson (1900) (Archies Fork of the Little Red River, Clinton, Arkansas). *Unio occidentalis* of Conrad has been entirely misunderstood by Simpson (1914, p. 112, as *Lampsilis occidentalis*). The Carnegie Museum possesses material of this form from Missouri, Arkansas, and Oklahoma. Its metropolis is in the Ozark Mountains.

### Obliquaria reflexa Rafinesque (1820).

*Obliquaria reflexa* Rafinesque, Simpson, 1914, p. 330.

Plate XIII, fig. 4.

*Records from Pennsylvania:*

Clapp, 1895 (Allegheny Co.).
Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co.).
Ortmann, 1909*b*, p. 193.

*Characters of the shell:* Shell rather small, hardly of medium size, thick and solid. Outline more or less rounded, subovate or subtrapezoidal, short and high, more or less pointed at the lower posterior end. Anterior and lower margins regularly rounded; lower margin ascending posteriorly, straight or slightly concave. Upper margin short, passing in a curve or blunt angle into the obliquely descending posterior margin. Beaks near, but somewhat in front of the middle, elevated over the hinge-line and incurved. Beak-sculpture consisting of a few (two to three) rather heavy, but not sharply defined, concentric bars, which have an indistinct tubercle upon the posterior ridge. Valves flat or convex, with a more or less distinct, rounded posterior ridge, generally with a shallow radial furrow, which may be obsolete. In front of this furrow stands a row of large, prominent knobs, which alternate with each other on the opposite valves. They are rounded, conical, or vertically compressed. Maximum number of these knobs on each valve, four or five. Posterior slope often ornamented with short, corrugated ridges.

Epidermis yellowish to brown, with indistinct darker concentric bands. There may be rays, fine, wavy, or broader; they sometimes spread over the surface, so that the whole epidermis appears dark green. In old specimens the epidermis is often uniformly brown.

Hinge well-developed. Pseudocardinals large, ragged, triangular, two in the left, one in the right valve. Laterals thick and short. Interdentum short and rather narrow. Beak cavity moderate. Dorsal muscle-scars in the beak-cavity. Anterior adductor-scars small, deeply impressed, posterior ones also small and distinct, but less impressed. Nacre silvery white, very rarely colored: I have seen only a few individuals from Alabama with purple nacre.

Sexual differences in the shell very uncertain. On the average, the females are more swollen, with the radial furrow indistinct, and the posterior lower margin not emarginate; while the male shells are more compressed, with the furrow more distinct, and the emargination of the lower margin more frequently developed. These differences, however, are slight, and there are shells in which the sex cannot

positively be determined by these characters. The females seem to remain smaller than the males.

| | | L. | H. | D. |
|---|---|---|---|---|
| *Size:* | 1. Industry, Cat. No. 61.4423 (♂) | 63 mm. | 53 mm. | 33 mm. |
| | 2. Cooks Ferry, Cat. No. 61.3583 (♂) | 56 " | 47 " | 28 " |
| | 3. Shippingport, Cat. No. 61.4756 (♂) | 56 " | 48 " | 27 " |
| | 4. Industry, Cat. No. 61.4122 (♂) | 46 " | 38 " | 22 " |
| | 5. Industry, Cat. No. 61.3585 (♀) | 39 " | 33 " | 20 " |

No. 1 is the largest at hand, surpassing the maximum length given by Scammon (1906).

*Soft parts* figured by Lefevre & Curtis, 1910, Pl. 1, fig. 3; 1912, Pl. 7, fig. 7; described and figured by Ortmann, 1912, p. 310, fig. 16. *Glochidia* figured by Lefevre & Curtis, 1910, p. 97, fig. M; 1912, p. 146, fig. M; Ortmann, 1912, Pl. 20, fig. 1; Surber, 1912, Pl. 2, fig. 39. According to Lefevre & Curtis the measurements are: $0.225 \times 0.230$; Surber: $0.225 \times 0.235$; Ortmann: $0.22 \times 0.22$ mm.

*Breeding season:* According to Lefevre & Curtis (1912), and also Surber (1912), the breeding season lasts from May to August: embryos are present from the end of May to July 9, and glochidia from June 20 to Aug. 8. Thus this species would appear to be *tachytictic*.

I have specimens with glochidia (and discharging), collected on May 19, 1911; June 20, 21, 22, 1911; July 13, 1911; July 29, 1914; and Aug. 6, 1910. These accord with the breeding season as given above, with the exception of the first date (May 19). This specimen is from Arkansas. It may be an exceptionally early date, or the breeding season may begin earlier in the South.

It would be well to try to obtain additional data. The species is adapted to a long breeding season. Being a rather primitive form, we may have here primitive or transitional conditions; or on the other hand the breeding season may have been re-adapted to more southern conditions, and may have become irregular.

*Remarks:* A very peculiar, ancient type in the subfamily, which cannot be mistaken for any other species on account of the peculiar shape and the unique sculpture. It is rather variable in outline and color.

There is a dwarf race in Lake Erie, light in color, which possibly deserves a varietal name; but since this form has not as yet been found in Pennsylvania, I shall not treat of it here.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Ohio River, Shippingport, Cooks Ferry, and Industry, Beaver Co.
Monongahela River, Charleroi, Washington Co. (G. A. Ehrmann).

*Other localities represented in the Carnegie Museum:*

*Lake-drainage:*

Lake Erie, Maumee Bay, Toledo, Lucas Co., Ohio; and La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).

*Ohio-drainage:*

Ohio River, Toronto, Jefferson Co., Ohio; St. Marys, Pleasants Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.

Pocatalico River, Raymond City, Putnam Co., West Virginia.

*Tennessee-drainage:*

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).

Paint Rock River, Paint Rock, Jackson Co., Alabama (H. H. Smith).

Clinch River, Solway, Knox Co.; Edgemoor and Clinton, Anderson Co., Tennessee.

*Western range:*

Mississippi River, Muscatine, Muscatine Co., Iowa (Hartman collection); Moline, Rock Island Co., Illinois (P. E. Nordgren).

Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).

Black River, Black Rock, Lawrence Co., Arkansas (H. E. Wheeler).

Spring River, Black Rock, Lawrence Co., Arkansas (A. A. Hinkley).

White River, Cotter, Baxter Co., Arkansas (A. A. Hinkley).

Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).

Verdigris River, Inola, Rogers Co., Oklahoma (F. B. Isely).

Bayou Pierre, De Soto Parish, Louisiana (L. S. Frierson).

Sabine River, Logansport, De Soto Parish, Louisiana (L. S. Frierson).

*Alabama-drainage:*

Forks of Black Warrior River, Walker Co., Alabama (H. H. Smith).

Coosa River, Wetumpka, Elmore Co.; Weduska Shoals and Wilsonville, Shelby Co.; Coosa Valley, Riverside, and Lock 4, St. Clair Co.; Fomby Shoals, Calhoun Co.; Greensport, St. Clair Co.; Minnesota Bend, Cherokee Co., Alabama (H. H. Smith).

*Distribution and Ecology* (See fig. 22): *Type locality,* Ohio River, Letart Falls, Meigs Co., Ohio (Rafinesque).

In Pennsylvania this species is restricted to the large rivers, the Ohio and Monongahela. I found it repeatedly in Beaver County, but it is rather rare. Farther down it becomes more abundant in the Ohio. In general, it seems to be restricted to the Ohio proper and a few of its larger tributaries, as the Muskingum (Dewey, 1856) and Scioto. Sterki (1907*a*) says that it is not found in the Tuscarawas, but in the Mahoning River. However I doubt the latter record, since Dean (1890) does not mention it, and since it is absent in the Beaver and Mahoning in Pennsylvania. The smallest stream in which I found this species, is the Pocatalico River in West Virginia, tributary to the Kanawha, and here it was scarce, and only occurred in the lower part of the stream. In Indiana also this species

is chiefly found in the larger rivers (Ohio, White, Wabash, Kankakee, according to Call, 1896*a* & 1900). It is more abundant in Illinois (Baker, 1906; Forbes & Richardson, 1913), and here it crosses over into the drainage of Lake Michigan (Calumet River, Baker, 1898*a*). It goes up the Mississippi in Illinois and Iowa, and reaches Wisconsin in the Fox River (Barnes, 1823), and southern Minnesota (Grant, 1886; Holzinger, 1888).

Southward it is found in the western tributaries of the Mississippi in eastern Kansas (Scammon, 1906), Arkansas (Call, 1895; Wheeler, 1918), Oklahoma and Louisiana (Vaughan, 1893; Frierson, 1899) and also in eastern Texas (Singley, 1893).

In the southern tributaries of the Ohio it has been reported from the Kentucky River (Rafinesque). It is common in the Cumberland (Wilson & Clark, 1914); and, in the Tennessee, it ascends in the region of Knoxville into the lower Clinch River (Carnegie Museum).

It turns up in the Alabama-drainage (Lewis, 1870 and 1877; Call, 1885; Carnegie Museum), and there goes as far as the Etowah River in northern Georgia (Call, 1885).

In the north it has been reported in Michigan from the Grand and Saginaw Rivers (Walker, 1894 & 1898), and it is also found in Lake Erie in Michigan and Ohio (Sterki, 1907*a*, and Walker, 1913). It has not been found in Pennsylvania, and Call's record (1895, p. 12) from western New York has not been substantiated by positive information. (It does not occur in the list of Marshall, 1895.)

It is clear that the species has crossed over into the lake-drainage from the upper Ohio system; but how it reached the Alabama-drainage remains to be investigated.

It is evident that it prefers large rivers, and it reaches Pennsylvania only in the large streams. According to my observations, it is found chiefly in the deep channel of the Ohio, upon the shell-banks, and is regularly taken by the clam-diggers. Scammon (1906) gives gravel-beds as the favorite habitat. But it seems to be also found on muddy bottoms (Baker, 1898*a*), and Call (1900) says, that it is almost ubiquitous with regard to its habitat. In Pocatalico River I found it in pure, shifting sand.

### Genus Cyprogenia Agassiz (1852).

Ortmann, 1912, p. 212; Simpson, 1914, p. 326.

Type *Obovaria stegaria* Rafinesque.

Only one species known from Pennsylvania.

CYPROGENIA STEGARIA (Rafinesque) (1820).

*Cyprogenia irrorata* (LEA) SIMPSON, 1914, p. 326; *Cyprogenia stegaria* (RAFINESQUE) VANATTA, 1915, p. 554.

Plate XIII, fig. 5.

*Records from Pennsylvania:*

Rhoads, 1899 (Ohio River, Beaver, Beaver Co.)
Ortmann, 1909*b*, p. 193.

*Characters of the shell:* Shell hardly of medium size, but solid. Outline subcircular, subtrapezoidal, or rounded triangular. Anterior and lower margins more or less rounded, but the latter tending in the posterior part to be straight or slightly concave. Upper margin short, slightly convex, forming a more or less distinct angle with the posterior margin, which is nearly vertical. Beaks slightly anterior to the middle, moderately inflated and elevated. Beak-sculpture rudimentary, consisting of a few slightly double-looped bars. Valves more or less convex, sometimes making the shell subglobular. Young specimens have a distinct, but rounded, posterior ridge, which becomes effaced in old ones. Generally there is a slight radial groove in front of the ridge, almost effaced in old specimens. Surface adorned by flat nodules, most distinct upon the posterior ridge and in front of the groove. Anterior part of the shell smooth, but there may be nodules in the groove and upon the posterior slope, where they may assume a radial arrangement. In old shells the nodules are much obliterated. The growth-rests are often marked by concentric, low ridges.

Epidermis light green or yellow, to light brown, ornamented with green mottlings, which fall into finer or broader, interrupted rays. The broad rays prevail upon the anterior part of the shell, the fine ones upon the posterior. In old shells the mottlings become indistinct. Concentric color-markings are absent or very faint.

Hinge well-developed. Pseudocardinals heavy, triangular, blunt and ragged, two in left, one in the right valve. Interdentum very broad and short. Laterals rather short, heavy. Beak-cavity moderately deep. Dorsal muscle-scars in the beak-cavity, upon the hinge-plate. Adductor-scars distinct, small, deeply impressed. Nacre silvery white, very rarely with a faint blush of pink.

I cannot see any sexual differences in the shell.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Godfrey, Cat. No. 61.4760 | 62 mm. | 57 mm. | 38 mm. |
| 2. do. Cat. No. 61.3581 | 56 " | 54 " | 34 " |
| 3. Industry, Cat. No. 61.4422 | 54 " | 52 " | 33 " |

I have not seen any larger specimens than No. 1.

The *soft parts* were described and figured by Lea (Obs. I, 1834, Pl. 5, figs. 6, 7), but fig. 7 is wrong; also (Obs. X, 1863, p. 433). Ortmann (1912, p. 313, fig. 17), and Lefevre & Curtis (1912, Pl. 7, fig. 8). The *Glochidia* were described by Sterki (1898, p. 19) and figured by Ortmann (1912, Pl. 19, fig. 6) and also by Surber (1912, Pl. 1, fig. 11). They measure, according to Sterki, 0.21 × 0.17; according to Surber, 0.210 × 0.185; according to Ortmann, 0.18 × 0.15 mm.

*Breeding season:* The species is *bradytictic* according to Lefevre & Curtis (glochidia in November). Surber found gravid females in October and November. I found them with eggs on Sept. 7 and 12, 1914, and Sept. 14, 1915, and Sept. 17, 1915, and Sept. 24, 1915.

*Remarks:* A well-marked species, distinguished by its somewhat subglobular shape, nodular surface, and the peculiar, mottled character of the color of the epidermis. The shape, however, is rather variable, and also the development of the nodules. The placentæ are mostly red, but I have found specimens (in Clinch River) with white placentæ.

*Localities represented in the Carnegie Museum:*

Ohio River, Industry, Beaver Co., Pennsylvania.

Allegheny River, Natrona, Allegheny Co.; Aladdin and Godfrey, Armstrong Co., Pennsylvania.

Tuscarawas River, Ohio (Holland collection).

Little Miami River, Xenia, Greene Co., Ohio (C. Goodrich).

Ohio River, St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio; and Cincinnati, Hamilton Co., Ohio (Juny collection).

Cumberland River, Cloyds Landing and Albany Landing, Cumberland Co., Kentucky (B. Walker, donor).

Tennessee River, Tuscumbia, Colbert Co., and Florence, Lauderdale Co., Alabama (H. H. Smith); Knoxville, Knox Co., Tennessee (Hartman collection).

Holston River, Mascot, Knox Co.; Hodges, Jefferson Co.; Turley Mill, Grainger Co., Tennessee.

Clinch River, Solway, Knox Co.; Edgemoor, Clinton, and Offutt, Anderson Co.; Black Fox Ford, Union Co.; Clinch River Station, Claiborne Co., Tennessee.

*Distribution and Ecology* (See fig. 22): *Type locality,* Ohio River (Rafinesque).

In Pennsylvania this species has been found in the Ohio and lower Allegheny. All specimens collected by myself (only seven) were dead shells, but some of them were quite fresh. However, this species must once have also existed in the Monongahela, at least as far up as the mouth of Cheat River, for I have found specimens in an old Indian garbage heap,[142] opposite Point Marion (See Ortmann, 1909*c*, p. 13).

According to Simpson (1900) it belongs to the Ohio, Cumberland, and Tennessee Rivers, and is mainly restricted to these large rivers, and a few of their larger

[142] Kitchen-midden. *Editor.*

tributaries. Thus, for instance, it occurs in Ohio, in the Muskingum at Marietta (Hildreth, 1828), in the Tuscarawas (Dean, 1890; Sterki, 1907*a*), and in the Scioto and Great Miami (Sterki). Sterki reports it also from the Mahoning River, but it has never been found in the Pennsylvanian part of it, and never anywhere else in the Beaver-drainage. In Indiana it is found besides the Ohio, in the White and Wabash Rivers (Call, 1896*a* and 1900). In Illinois it occurs only in the Wabash (Baker, 1906). A number of localities are known in Kentucky, Tennessee, and northern Alabama in the Cumberland and Tennessee systems (See Wilson & Clark, 1914).

West of the Mississippi it has been reported only by Call (1895) from the St. Francis River, Wittsburg, Cross Co., and Saline River, Benton, Saline Co., Arkansas, but this is questioned by Simpson, and correctly, as I think. I know that this species is represented in this region (Missouri, Kansas, Arkansas, Oklahoma) by another, *C. aberti* (Conrad), which has apparently been mistaken for the one under consideration.

In the Ohio between Pittsburgh and Cincinnati this species is found in the mussel-beds in the deep channel of the river, on gravelly bottoms with steady currents. In the Tennessee-drainage I found it frequently in firmly packed gravel, in strongly flowing water, in rivers of medium size (Clinch, Holston).

### Genus Obovaria Rafinesque (1820).[143]

Ortmann, 1912, p. 320; Simpson, 1914, p. 289.

Type *Unio retusa* Lamarck.

The genus is divided into two subgenera.

#### Key to the Subgenera of Obovaria.

$a_1$. Shell rounded or subovate, upright, with nearly central, or anteriorly incurved beaks. Pseudocardinals divergent, not parallel to the laterals. Epidermis more or less brown. Nacre often red or purplish. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . Subgenus *Obovaria*.

$a_2$. Shell ovate or elliptical, oblique; beaks quite anterior. Pseudocardinals in adult specimens subparallel to the laterals. Epidermis greenish. Nacre white. . . . . . . . . . . . . . . . . Subgenus *Pseudoön*.

### Subgenus Obovaria Simpson (1900).

Ortmann, 1912, p. 321; Simpson, 1914, p. 290.

Type *Obovaria* (*Unio*) *retusa* Lamarck.

Two species and one variety are found in Pennsylvania.

#### Key to the Forms of Obovaria.

$a_1$. Shell as high as, or higher than, long. Beaks much elevated and much incurved. Nacre deep purple with white margin. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *O. retusa*.

[143] Not "1819," as Simpson gives the date. In 1819 Rafinesque published this name, but as "nomen nudum."

$a_2$. Shell not higher than long. Beaks less elevated and not much incruved. Nacre white or purplish.
$b_1$. Shell swollen. Diameter sixty percent of the length or more. . . . . . . . . . . . . . . . . . . . *O. subrotunda.*
$b_2$. Shell compressed. Diameter less than sixty percent of length. . . . . . . . . . . *O. subrotunda levigata.*

## OBOVARIA (OBOVARIA) RETUSA (Lamarck) (1819).

*Obovaria retusa* (LAMARCK) SIMPSON, 1914, p. 290.

Plate XIII, figs. 6, 7.

*Records from Pennsylvania:*

Ortmann, 1909*b*, p. 192.

*Characters of shell:* Shell of medium size, heavy and solid. Outline subcircular or subovate, about as high as long, or even higher than long, upright. Anterior, lower, and posterior margins almost regularly rounded, only with a blunt lower posterior angle in the male, and a slight emargination in this region in the female. Upper margin short, convex. Beaks swollen and elevated, situated near the middle of the shell, but strongly incurved forward. Beak-sculpture rudimentary, never distinctly seen by the writer. Valves strongly convex, without a distinct posterior ridge. No sculpture on the outer surface, but irregular concentric ridges, corresponding to the growth-lines, are often present.

Epidermis light to dark brown, generally quite uniformly dark brown upon the disk, while the posterior slope is lighter, pale brown or yellowish. The lighter color is not sharply marked off from the darker part, and often the contrast is not evident at all. Upon the lighter posterior slope, there are sometimes a few feeble greenish rays, and in young specimens, such rays may be indicated by mere traces upon the disk, but normally there are no rays at all.

Hinge well-developed. Pseudocardinals very heavy, stumpy, ragged, triangular, one in right, two in left valve, the latter divergent and not parallel to the laterals. Interdentum broad and short. Laterals short, thick and heavy. Beak-cavity rather deep and narrow. Dorsal muscle-scars upon the inside of the hinge-plate. Adductor-scars distinct and deeply impressed. Nacre of various shades of purple, generally very deeply colored, but the margin outside of the mantle-scar is generally white.

Sexual differences of the shell moderate, but distinctly marked. In the male, the lower and posterior margins form a regular curve or meet in an indistinct, rounded lower posterior angle. In the female the disk shows a slight swelling, forming a slight projection in the posterior part of the lower margin situated at a lower level than the posterior angle of the male. Above this swelling, and behind it, the shell is slightly depressed, and the posterior margin ascends straight or is

somewhat concave, before it reaches the level of the posterior angle of the male. Thus the female shell has two blunt posterior angles on the hind end, but this structure may be rather obscure. The female shell is generally higher than that of the male, and the male seems to grow to a slightly larger size than the female.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Industry, Cat. No. 61.3556 (♂) | 58 mm. | 58 mm. | 37 mm. |
| 2. do. " " 61.3555 (gravid ♀) | 58 " | 64 " | 39 " |

*Soft parts* (See Ortmann, 1912, p. 321, 322, fig. 20). *Glochidia:* Ortmann, 1912, Pl. 19, fig. 9; Surber, 1912, Pl. 3, fig. 47. Measurements: 0.22 × 0.27 (Ortmann); 0.240 × 0.295 (Surber).

*Breeding season:* On Aug. 29, 1908 and Sept. 7, 1914, I found specimens with eggs, and on Sept. 22, 1910 specimens with glochidia. This indicates the beginning

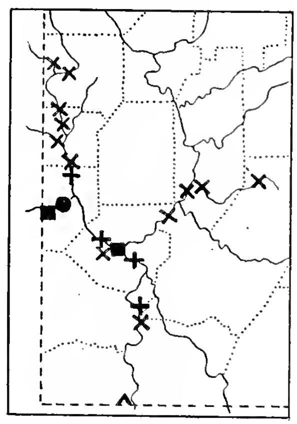

FIG. 23.

● *Obovaria retusa.*
■ *Obovaria olivaria.*
+ *Obovaria subrotunda.*
× *Obovaria subrotunda levigata.*
> *Obovaria subrotunda levigata* (from Indian garbage heap).

of the season in autumn. Surber (1912) reports this species as gravid in September. It probably is *bradytictic.*

*Remarks:* There is no trouble in recognizing this species; the shape and the color of the nacre are quite unique.

*Localities represented in the Carnegie Museum:*

Ohio River, Industry, Beaver Co., Pennsylvania.

Ohio River, Toronto, Jefferson Co., Ohio; Wheeling, Ohio Co., West Virginia; (W. F. Graham); St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.

Tennessee River, Knox Co., Tennessee (Smith collection).

Clinch River, Clinton, Anderson Co., Tennessee.

*Distribution and Ecology* (See fig. 23): *Type locality*, unknown. The original type locality (Nova Scotia) is erroneous.

Only two specimens have ever been found in Pennsylvania, both at the same place in Beaver Co. This marks the farthest point upstream in the Ohio of the range of this species.

Simpson (1900) gives the range as "Ohio, Cumberland, and Tennessee River systems." To these it seems to be restricted, and in the middle and upper Ohio, it is also restricted to this river, and does not go into the tributaries (For Ohio see Sterki, 1907*a*). In Indiana and Illinois, however, it has spread into the larger affluents. Call (1896*a*, and 1900) reports it for Indiana from the Wabash, White, Whitewater, Patoka, Eel, and Kankakee,[143a] and Baker (1906) gives it for Illinois from the Wabash and Spoon Rivers, as far north as La Salle County. It is also found in the lower Ohio (in Indiana and Illinois), and in the Mississippi River, according to Call (1895, p. 47) "north of Arkansas," but it is missing in Witter's list (1878) of the shells from Muscatine, Iowa, and in Pratt's list (1876) from Davenport, Iowa.

*O. retusa* is known from the Cumberland River (Wilson & Clark, 1914; also previously reported from Nashville, Davidson Co., Tennessee, by Call, 1895). In the Tennessee it goes up to the region of Knoxville, entering here the lower Clinch.

It is unknown from west of the Mississippi and from the Gulf-drainage, and thus the species is rather restricted in its distribution, and is apparently a form of the larger rivers. In the Ohio between Pittsburgh and Cincinnati I found it associated with the bank-forming shells, and it is here regularly taken by the clam-diggers, but rejected on account of the color of the nacre. In a few cases, I collected it in smaller branches of the Ohio in fine gravel, most abundantly at Portland, Ohio.

### Obovaria (Obovaria) subrotunda (Rafinesque) (1820).

*Obovaria circulus* (Lea) Simpson, 1914, p. 291; *Obovaria subrotunda* (Rafinesque) Vanatta, 1915, p. 552.

Plate XIV, figs. 1, 2.

*Records from Pennsylvania:*

Lea, Obs. I, 1834 (Monongahela River, Pittsburgh).

Harn, 1891 (western Pennsylvania).

Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co.) (reported as *U. lens*).

Ortmann, 1909*b*, p. 192.

[143a] Also from the Maumee-drainage (St. Joseph River) but this surely needs confirmation. It is also said to be present in a few small lakes in northern Indiana.

*Characters of the shell:* Shell rather small, but thick and solid. Outline irregularly subcircular, about as high as long, or slightly longer than high, upright. Anterior and lower margins forming a regular curve. Lower margin ascending posteriorly, more or less straight, meeting the obliquely descending posterior margin in a blunt angle in the male. In the female this angle is less distinct, and the posterior margin becomes nearly vertical. Upper margin short, convex. Beaks more or less swollen, slightly elevated, situated close to the middle of the shell, not incurved. Beak-sculpture rudimentary, consisting of about four or five weak bars, slightly sinuated in the middle, angled behind, and disappearing upon the posterior slope. Shell swollen, diameter at least sixty percent of the length. Convexity of valves rather uniform, without any posterior ridge. No sculpture upon the disk.

Epidermis light to dark brown, in young specimens sometimes yellowish green; the disk is generally uniformly dark brown, while the posterior slope is light brown or yellowish, sharply contrasted with the disk, but the contrast becomes less distinct toward the lower margin of the shell. In light-colored young shells, there are sometimes faint traces of greenish rays, but generally rays are entirely absent.

Hinge well-developed. Pseudocardinals strong, stumpy, ragged, triangular, one in right, two in left valve, the latter divergent, and not parallel to the laterals. Interdentum moderate or narrow. Laterals short, strong. Beak-cavity moderately deep. Dorsal muscle-scars partly in the beak-cavity, partly upon the hinge-plate. Adductor-scars distinct, and rather deeply impressed. Nacre silvery white, or with more or less pink or light purple inside of the marginal zone.

Sexual differences in the shell present, but not strongly pronounced, and sometimes obscure. In the male the posterior part of the lower margin ascends and meets the posterior margin in a blunt angle, which, however, may be very indistinct. In the female the lowermost point of the lower margin is situated more backward, and then the margin ascends more suddenly, curving up into the posterior margin more gradually, without forming a distinct angle. Thus the posterior margin appears more vertical, the shell is rather truncate posteriorly, and is rather more elevated. Besides, there is distinctly a difference in size, the female being considerably smaller than the male.

| | | | L. | H. | D. | Pr.ct. |
|---|---|---|---|---|---|---|
| *Size:* | (Males) | 1. Neville Island, Cat. No. 61.1798 | 59 mm. | 52 mm. | 38 mm. | .64 |
| | | 2. do. Cat. No. 61.1598 | 49 " | 45 " | 32 " | .65 |
| | (Females) | 3. Charleroi, Cat. No. 61.2840 | 50 " | 48 " | 34 " | .68 |
| | | 4. do. " " do. | 38 " | 37 " | 24 " | .63 |

*Soft parts* (See Ortmann, 1912, p. 323). *Glochidia* identical with those of var. *levigata*, 0.20 × 0.23 mm., while Surber (1915, p. 7, fig. 8) gives: 0.170 × 0.215 mm.

*Breeding season:* I found the typical *subrotunda* gravid with glochidia on Sept. 22, 1910, and gravid and discharging on May 25, 1911. A female with eggs was found on Sept. 6, 1914. Surber gives June 9, 1913 for glochidia. This would agree with the *bradytictic* character of the species. A single individual, however, discharging glochidia, was received from A. A. Hinkley, collected on Aug. 9, 1912 in the Wabash River. Probably this specimen was exceptionally belated.

*Remarks:* The more or less circular outline and subglobular shape, the almost central beaks, and the light color of the posterior slope, serve to distinguish this species. But there is great variability in the outline, and also in the convexity of the valves, and, according to the latter, a variety (*levigata*) must be distinguished from the main species, which will be treated below, and it should be pointed out, that the latter is closely connected with the normal form by intergrades.

Another "species," distinguished by Lea (and Simpson), *O. leibi* (Lea), is nothing but the form from Lake Erie of *O. subrotunda*. It differs merely in its smaller size (largest at hand: L. 42, H. 38, D. 26 mm.), and has, like many lake-forms, more regular and more distinct growth-rests. It is also sometimes lighter in color. I shall not treat of it here in detail, since I have not yet found it on the Pennsylvanian shores of the lake.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Ohio River, Neville Island, Allegheny Co.
Monongahela River, Charleroi, Washington Co. (G. A. Ehrmann).
Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).

*Other localities represented in the Carnegie Museum:*

Ohio River, St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio.
Wabash River, New Harmony, Posey Co., Indiana (A. A. Hinkley).
West Fork White River, Riverside, Greene Co., Indiana (J. D. Haseman).
Little Kanawha River, Grantsville, Calhoun Co., West Virginia (W. F. Graham).
Elk River, Shelton and Clay, Clay Co.; Gassaway and Sutton, Braxton Co., West Virginia.
Holston River, Mascot, Knox Co., Tennessee.

*Distribution and Ecology* (See fig. 23): *Type locality*, Ohio River (Rafinesque). (Vanatta says: "Kentucky River".)

In Pennsylvania the typical *O. subrotunda* is restricted to the Ohio, the Beaver, and the lower Monongahela, and it should be kept in mind, that just in this region more compressed specimens turn up, which establish the transition toward the

var. *levigata*. Farther up only the latter is found, but farther down the Ohio, *O. subrotunda* is common, and goes up into some of the tributaries (Little Kanawha and Elk Rivers). The form from Elk River is peculiar, dwarfed, but with the average diameter of sixty-one percent of the length.[144] Sterki (1907*a*) believes that *circulus* (*subrotunda*) is the male, and *lens* (*levigata*) the female. This is not correct, for relying on Lea's figures, just the opposite would be true. On account of this confusion it is not possible to trace the exact distribution of the two forms in Ohio.

In the rest of the range the two forms have not been kept strictly separate. It suffices here to say, that the range of the true *subrotunda* covers, as Simpson (1900) says: "the Ohio, Tennessee, and Cumberland river systems," that it does not extend west of the Mississippi (Call, 1885), and that it is restricted to larger rivers. This is substantiated by the material in the Carnegie Museum from West Virginia, Kentucky, and Tennessee. Wilson & Clark (1914) report this form from the upper Cumberland.

*O. subrotunda* has also been reported from the south in the Alabama and Tombigbee drainages (Lea and Lewis, 1870), but this is questioned by Simpson. A few specimens from this region in the Carnegie Museum resemble *O. subrotunda* very much, but I have not enough material to decide the question.

This species also crosses over into the lake-drainage in southern Michigan and Ohio. Specimens from Lake Erie proper form a peculiar race (var. *leibi*), and appear more closely related to *subrotunda*, than to var. *levigata*. In the tributaries of the lake (Maumee-drainage) the var. *levigata* is present. (See below.)

*O. subrotunda* in the Ohio prefers the shell-banks, in gravel and steady currents. It is also found in small branches of the river, in the gravel of the riffles.

### Obovaria (Obovaria) subrotunda levigata (Rafinesque) (1820).

*Obovaria lens* (Lea) Simpson, 1914, p. 293; *Obovaria levigata* (Rafinesque) Vanatta, 1915, p. 552.

Plate XIV, figs. 3, 4.

*Records from Pennsylvania:*

Rhoads, 1899 (specimens from Beaver River, Wampum, Lawrence Co.).
Ortmann, 1909*b*, p. 192 (included in *circulus*).

*Characters of the variety:* Shell similar to that of typical *subrotunda*, but more compressed, the diameter less than sixty percent of the length. Sometimes, but

[144] But in Elk River also the diameter decreases in the upstream direction. At Sutton specimens were found, which should be called var. *levigata* according to the diameter.

not always, the shell is of a lighter color. When lighter, the color is greenish or brownish olive upon the disk, and yellowish upon the posterior slope.

| | | | L. | H. | D. | Pr.ct. |
|---|---|---|---|---|---|---|
| *Size:* | (Males) | 1. Wampum, Cat. No. 61.2842 | 67 mm. | 57 mm. | 33 mm. | .49 |
| | | 2. do. " " do. | 60 " | 51 " | 33 " | .55 |
| | | 3. do. " " do. | 50 " | 44 " | 25 " | .50 |
| | (Females) | 4. Wampum, Cat. No. 61.2842 | 47 " | 44 " | 25 " | .53 |
| | | 5. Natrona, Cat. No. 61.4116 | 40 " | 36 " | 22 " | .55 |
| | | 6. Creekside, Cat. No. 61.3269 | 37 " | 31 " | 19 " | .51 |

The lowest diameter ever observed is in a specimen from West Fork River in West Virginia, where it is forty-six percent of the length.

*Soft parts* identical with those of *O. subrotunda* (See Ortmann, 1912, p. 328). *Glochidia* figured by Ortmann, 1911, Pl. 89, fig. 15. They measure: $0.20 \times 0.23$ mm.

*Breeding season:* Glochidia have been found on Sept. 21, 1908, and again on May 23, 1911; May 24, 1911; and May 27, 1908. On the latter date, discharge has been observed. This indicates, that the form is *bradytictic.*

*Remarks:* The essential difference between this and the normal form is the compression of the valves. It is true that the color is also often lighter (as pointed out by Lea) but this does not hold good for the average of the Pennsylvanian specimens. As is evident by the measurements given, the diameter of the shell is less than in *O. subrotunda;* but it must be noted, that at certain places the two forms are found associated, and that they actually and insensibly pass into each other. The dividing line at the diameter of sixty percent is entirely artificial, and does not express natural conditions. It has been introduced, as in similar cases, simply for the sake of convenience.

In the smaller creeks, var. *levigata* is found rather exclusively, while *subrotunda* prevails in the Ohio. The transitional zone between them is precisely in the region of Pittsburgh. Thus these forms must be regarded as varieties of one and the same species.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Ohio River, Neville Island, Allegheny Co.
Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Mahoning River, Mahoningtown, Lawrence Co.
Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Clarksville, Mercer Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Allegheny River, Natrona, Allegheny Co.; Godfrey, Armstrong Co.
Crooked Creek, Rosston, Armstrong Co.; Creekside, Indiana Co.

Monongahela River, Charleroi, Washington Co. (G. A. Ehrmann).[145]

*Other localities represented in the Carnegie Museum:*

*Lake-drainage:*

St. Joseph River, Fort Wayne, Allen Co., Indiana (C. Goodrich).

*Ohio-drainage:*

Tuscarawas River; Ohio (Holland collection).
West Fork River, Lynch Mines, Harrison Co.; Lightburn and Weston, Lewis Co., West Virginia.
Little Kanawha River, Burnsville, Braxton Co., West Virginia.
North Fork Hughes River, Cornwallis, Ritchie Co., West Virginia.
Elk River, Sutton, Braxton Co., West Virginia.
Pocatalico River, Raymond City, Putnam Co., West Virginia.
Coal River, Sproul, Kanawha Co., West Virginia.
Mud River, Milton, Cabell Co., West Virginia.
Levisa Fork Big Sandy River, Prestonsburg, Floyd Co., Kentucky.
Licking River, Farmer, Rowan Co., Kentucky.

*Tennessee-drainage:*

Bear Creek, Burleson, Franklin Co., Alabama (H. H. Smith).
Elk River, Estill Springs, Franklin Co., Tennessee (H. H. Smith).
Hurricane Creek, Gurley, Madison Co., Alabama (G. H. Clapp, donor).
Flint River, Maysville, Madison Co., Alabama (H. H. Smith).
Paint Rock River, Paint Rock, Holly Tree, Trenton, and Princeton, Jackson Co., Alabama (H. H. Smith).
South Chickamauga Creek, Ringgold, Catoosa Co., Georgia.
Holston River, Holston Station, Grainger Co., Tennessee.

*Distribution and Ecology* (See fig. 23): *Type locality*, Kentucky River (Rafinesque).

As has been mentioned above, it is hard to trace the distribution of this form in its relation to *O. subrotunda*. Simpson (1900) gives only: "Ohio-drainage and southern Michigan."

According to my experience this is the small-stream-form of *O. subrotunda*, and wherever the latter tends to ascend into the tributaries of the larger rivers, it turns into *levigata*. This is true in the Beaver-drainage, in the Allegheny and Monongahela in Pennsylvania. But this form is not found in all the tributaries. Upon the whole it is one of the rarer shells in our state. Rather compressed shells are found down the Ohio for a certain distance, but they become scarcer and scarcer. I have traced them down as far as Portland, Meigs Co., Ohio. But since there are only isolated specimens among large numbers of typical *subrotunda*, I have not taken the trouble of picking them out.

[145] This form must have once existed in the Monongahela near Point Marion, Fayette Co., for specimens found in an Indian garbage heap are this (Ortmann, 1909c, p. 13). It is abundant in the upper Monongahela system (see below).

In the tributaries of the Ohio in West Virginia it appears to be the rule that *levigata* is the form of the smaller streams. In Ohio aside from the Mahoning River (Dean) this form is positively known to occur in the Tuscarawas River (Dean, 1890, also Carnegie Museum), and it has been reported from the upper Scioto, Columbus, Franklin Co. (Lea), and it has crossed over into the lake-drainage (St. Joseph River).

Further, Call (1885) cites it from Tennessee in Elk River, Lincoln Co., but says that it is identical with "*circulus.*" That it is actually there, a little farther up, is shown by specimens in the Carnegie Museum. It also is found in a number of the tributaries of the Tennessee in northern Alabama and northern Georgia, and has been detected in the Holston above Knoxville (very rare at this point).

Ecologically this form is in Pennsylvania and West Virginia distinctly sand-loving. It is found in bars of sand or fine gravel, and is even not averse to shifting sand.

### Subgenus PSEUDOÖN Simpson (1900).

Ortmann, 1912, p. 321; Simpson, 1914, p. 298.

Type *Amblema olivaria* Rafinesque.

Only one species is found in Pennsylvania.

### OBOVARIA (PSEUDOÖN) OLIVARIA (Rafinesque) (1820).

*Obovaria ellipsis* (LEA) SIMPSON, 1914, p. 299; *Obovaria olivaria* (RAFINESQUE) VANATTA, 1915, p. 553.

Plate XIII, figs. 8, 9.

*Records from Pennsylvania:*

Stupakoff, 1894 (Allegheny Co.).
Ortmann, 1909*b*, p. 192.

*Characters of the shell:* Shell of medium size, thick and solid. Outline elliptical or subovate, longer than high, strongly oblique. Anterior and lower margins forming a regular curve, the lower margin curving up behind, and joining the posterior margin in a curve, without forming an angle, but posterior end of shell more narrowly rounded than the anterior. Upper margin convex, passing gradually into the descending posterior margin. Beaks swollen, directed obliquely forwards, incurved, and located much anteriorly, but generally a little behind the most anterior part of the anterior margin, elevated somewhat above the hinge-line. Beak-sculpture rudimentary, consisting of four or five fine bars, which are sinuate in the middle. The posterior part of the bars is rudimentary and disappears upon

the posterior slope. There are specimens with well preserved beaks, where there is hardly a trace of these bars. Valves rather convex, chiefly so towards the beaks. No posterior ridge developed. No sculpture upon the disk.

Epidermis normally greenish olive, lighter or darker, but shading to yellowish, and in old specimens to brownish olive, but never dark brown. Color generally rather uniform, and growth rests not marked by distinct concentric bands. In some specimens, chiefly young ones, faint green rays are discernible, but rays are mostly absent.

Hinge well-developed. Pseudocardinals heavy and solid, stumpy or slightly elongated, one in right, two in left valve, not distinctly divergent, and becoming, in older shells, subparallel to the laterals. Laterals moderately long, heavy. Interdentum moderately developed. Beak-cavity not very deep. Dorsal muscle-scars in the beak-cavity. Adductor-scars distinct and deeply impressed, chiefly the anterior ones. Nacre silvery white.

Sexual differences present in the shell, but not very strongly marked. In the male the lower margin curves up backward from about the middle, and the posterior end of the shell is distinctly narrowed, sometimes almost bluntly pointed. In the female the lower margin begins to ascend at a point back of the middle, and curves up more broadly, so that the shell is less narrowed behind, and the posterior end is broader and more evenly rounded. In consequence of this the female shell appears higher and shorter. The males also grow to a size distinctly larger than the females. However, there are females in which the characteristic shape is poorly developed, and sometimes males are more broadly rounded behind, so that it is not always possible to positively tell the sex by the shape of the shell.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Industry, Cat. No. 61.3561 (gravid ♀) | 66 mm. | 54 mm. | 36 mm. |
| 2. Cooks Ferry, Cat. No. 61.4420 (♀ ?) | 59 " | 47 " | 34 " |
| 3. Industry, Cat. No. 61.3561 (♀) | 42 " | 32 " | 20 " |
| 4. Toronto, Cat. No. 61.5444 (♂) | 76 " | 60 " | 40 " |
| 5. Portland, Cat. No. 61.4776 (♂) | 70 " | 55 " | 36 " |
| 6. do. " " do. (♂) | 60 " | 49 " | 31 " |

*Soft parts:* Ortmann, 1912, p. 323. *Glochidia, ibid.*, Pl. 19, fig. 11; Surber, 1912, Pl. 2, fig. 25. According to Surber they measure: $0.210 \times 0.265$; while my figures are: $0.19 \times 0.22$ mm.

*Breeding season:* Gravid females were collected: Aug. 29, 1908 (eggs); Sept. 22, 1910 (glochidia); Sept. 24, 1910 (glochidia); and June 20 and 21, 1911 (glochidia, discharging). Although these represent only a few dates, it is clearly shown,

that this is a *bradytictic* form, breeding from August to June. Surber's records also confirm this (1912, p. 7): February, May, June, and August, September, October, November, December.

*Remarks:* A species easily recognized by the short-elliptical or ovate outline, with the margins more regularly rounded (without angles) than in any other species, by its oblique shape, with much anterior beaks, convex shell, and greenish-olive color. The hinge-teeth are also quite peculiar.

In the outline and convexity of the shell there is much variability, the posterior end being more broadly or more narrowly rounded, and the beaks being more or less anterior. In old shells the beaks are generally more anterior, sometimes even being at the anterior end. The color also is somewhat variable, and old shells are often discolored and dull brown, but not dark brown. In young shells the pseudocardinals are somewhat divergent and not so distinctly parallel to the laterals.

*Localities represented in the Carnegie Museum:*

Ohio River, Industry and Cooks Ferry, Beaver Co., Pennsylvania.

Ohio River, Toronto, Jefferson Co., Ohio; St. Marys, Pleasants Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.

West Fork White River, Riverside, Greene Co., Indiana (J. D. Haseman).

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).

Mississippi River, Moline, Rock Island Co., Illinois (P. E. Nordgren).

Kansas River, Lawrence, Douglas Co., Kansas (R. L. Moodie).

Black River, Black Rock, Lawrence Co., Arkansas (H. E. Wheeler).

*Distribution and Ecology* (See fig. 23): *Type locality,* Kentucky River (Rafinesque).

One of the rarest species in Pennsylvania. It reaches the state only in the Ohio River in Beaver and Allegheny Counties, and does not extend upstream beyond Pittsburgh.

Farther down the Ohio, it is found only in this river, and does not go into the tributaries in the state of Ohio (Sterki, 1907*a*), but it is rather common here. It has a wider distribution in Indiana and Illinois. In Indiana (Call, 1896*a* and 1900) it is practically all over the state, and crosses over into the lake-drainage (Maumee), and goes even farther north into southern Michigan (Detroit, Grand, and Saginaw Rivers, according to Walker, 1892, 1894, and 1898). It has been reported from Lake Erie (Walker, 1913), and also from western New York, Niagara River and Cayuga Lake (Marshall, 1895), and from the lower St. Lawrence in Canada (Ottawa, Montreal, and Quebec, see Marshall, 1895; Bell, 1859; Whiteaves, 1863). However this northeastward expansion of the range is peculiar in its detail, and should

be studied more closely; the species has not been observed on the Pennsylvanian shores of Lake Erie.

Westward, it is abundant in Illinois (Baker, 1906), chiefly in the larger rivers, the Ohio, Wabash, Illinois, Spoon, and Kankakee, and also in the Mississippi, where it is also found on the Iowa side, and goes up to southern Wisconsin (Lapham, 1860) and Minnesota (Grant, 1886, Holzinger, 1888).

Thence westward and southwestward, records are at hand from Missouri (Utterback, 1916), Kansas (Scammon, 1906). Simpson (1900) also mentions the Arkansas River. The Carnegie Museum has it from Black River in northern Arkansas.

South of the Ohio it is found in the Kentucky River (type locality) and in the Cumberland (Wilson & Clark, 1914). It was reported from Nashville, Davidson Co., Tennessee, by Marshall (1895). A single specimen is in the Carnegie Museum from the Tennessee in northern Alabama. Farther up above Chattanooga it is absent. I never saw it there, and it is absent in Lewis' list (1871).

As to its ecology I am able to say from personal experience, that it is a species belonging to the shell-banks of the Ohio, in the deep channels, with strong, steady currents. It is also in the smaller branches in (at low stages) shallow water, in gravel. Scammon (1906) calls it "a lover of water of moderate depth and of sandy river-beds."

### Genus Actinonaias Crosse & Fischer (1893).

*Nephronaias* Crosse & Fischer; Ortmann, 1912, p. 324; *Actinonaias* Frierson, 1917, p. 48.[146]

Type *Unio sapotalensis* Lea.

The only species known from Pennsylvania has been placed by Simpson in *Lampsilis*. But whatever the final name of the genus may be, it is surely not *Lampsilis*, because entirely lacking the characteristic structures found in the female in that genus.

### Actinonaias ligamentina (Lamarck) (1819).

*Lampsilis ligamentina* (Lamarck) and *Lampsilis ligamentina nigrescens* Simpson, 1914, pp. 79 and 82.

Plate XIV, figs. 5, 6.

*Records from Pennsylvania:*

Harn, 1891 (western Pennsylvania).
Stupakoff, 1894 (Allegheny Co.).

[146] Simpson's *Nephronaias* contains an assemblage of heterogenous species, belonging even to different subfamilies. The nomenclature of this genus is still provisional, the structure of the type-species being as yet incompletely known.

Marshall, 1895 (Allegheny River, Warren Co.).
Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co.; Beaver River, Wampum, Lawrence Co.).
Ortmann, 1909*b*, p. 190.

*Characters of the shell:* Shell large, thick, and heavy. Outline subelliptical or subovate, more or less elongated. Anterior margin rounded, lower margin and upper margin together with the posterior margin forming rather regular curves, joining posteriorly in a blunt point, situated below the horizontal middle line of the shell. Beaks moderately swollen, little elevated, situated anterior to the middle of the shell. Beak-sculpture poorly developed, consisting of a few fine, indistinct bars, which have a tendency to be double-looped. Valves moderately and rather uniformly convex; posterior ridge faint, indistinct, or obliterated. No sculpture upon the disk.

Epidermis yellowish, greenish, or brownish-olive, often with more or less distinct rays. Rays present chiefly in young individuals, broad and continuous, sometimes sharply marked, sometimes obscure, covering the whole shell. In other cases, there are hardly any traces of rays, and in old specimens the epidermis is uniformly brown or blackish. Concentric bands of color are sometimes present.

Hinge well-developed. Pseudocardinals normally one in right, two in left valve, but often additional ones are present. The normal pseudocardinals are strong and heavy, ragged, subtriangular, divergent. Interdentum narrow, rather long. Laterals long, strong, heavy. Beak-cavity moderate. Dorsal muscle-scars in beak-cavity and upon the hinge-plate. Adductor-scars distinct, well impressed, chiefly the one anterior. Nacre silvery white, but often discolored, in very rare cases pinkish.[147]

Sexual differences present, but slight. In the male the lower margin is rather evenly curved. In the female it is more curved out in its posterior part, so that the poterior point of the shell is more elevated, and the whole posterior end of the shell appears higher and more rounded. But in many cases, it is hard, or even impossible, to tell the sex from the shape of the shell. Wherever the posterior expansion is distinctly developed, we may be sure to have a female before us.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Edinburg, Cat. No. 61.3491 (♀ gravid) | 155 mm. | 95 mm. | 61 mm. |
| 2. Pulaski, Cat. No. 61.4059 (♀) | 147 " | 94 " | 63 " |
| 3. Edinburg, Cat. No. 61.3491 (♂) | 124 " | 76 " | 51 " |
| 4. Cooks Ferry, Cat. No. 61.4791 (♂) | 93 " | 65 " | 41 " |

[147] Such specimens have never been found in Pennsylvania, but I have a specimen with pinkish nacre from Blennerhasset Island, near Parkersburg, West Virginia.

*Soft parts* (See Ortmann, 1912, p. 325). *Glochidia:* Lea (Obs. VI, 1858, Pl. 5, fig. 18) Ortmann (1911*b*, Pl. 89, fig. 16). Surber, 1912, Pl. 2, fig. 18. My measurements are: 0.22 × 0.24; those of Surber: 0.220 × 0.260 mm.

*Breeding season:* Records for gravid females are rather complete, and cover the period from Aug. 3 to Oct. 24, and from March 21 to May 20. This is a *bradytictic* form with the interim in June and July. According to Surber (1912, p. 7), glochidia are present from September to July, with the interim in August (in Iowa).

*Remarks:* Externally a form of simple appearance, without striking characteristics. It may be recognized by its large size and heavy shell, of a rather regular subelliptical outline, with more or less distinct, broad rays. Young shells might be mistaken for *Eurynia iris*, or even for *Lampsilis luteola*, but these latter are both more elongated, and differ somewhat in color.

*A. ligamentina* varies a good deal. The southern variety, *gibba* of Simpson, is not represented in Pennsylvania. Humped specimens (the character of *gibba*), are found, but they have the earmarks of cripples. The var. *nigrescens* (Simpson, 1914, p. 82) reported from Allegheny County, is merely an individual variation, which is assumed occasionally by old shells, and does not deserve a name.

There are peculiar forms in Arkansas, which generally go by the name of *ligamentina*. They differ from the normal form in the color of the epidermis and of the nacre. I have not made up my mind with regard to these, and in the following list of localities they have been omitted, as has been the var. *gibba*. Only undoubted representatives of *A. ligamentina* are recorded.

*Localities in Pennsylvania represented in the Carnegie Museum:*

*Ohio-drainage:*

Ohio River, Smith's Ferry, Shippingport, Cook's Ferry, and Industry, Beaver Co.; Beaver, Beaver Co. (W. E. C. Todd); Dead Man's Island, Shousetown, and Neville Island, Allegheny Co.; Coraopolis (S. N. Rhoads) and Edgeworth (G. H. Clapp), Allegheny Co.

Little Beaver Creek, Cannelton, Beaver Co. (Miss Vera White).

*Beaver-drainage:*

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).

Connoquenessing Creek, Ellwood City, Lawrence Co. (G. H. Clapp & H. H. Smith).

Slipperyrock Creek, Wurtemberg, Lawrence Co.

Mahoning River, Mahoningtown, Coverts, and Edinburg, Lawrence Co.

Shenango River, Harbor Bridge and Pulaski, Lawrence Co.

*Allegheny-drainage:*

Allegheny River, Sandy Creek, Harmarville, and Natrona, Allegheny Co.; Braeburn, Westmoreland Co.; Schenley, Aladdin, Godfrey, Johnetta, Kelly, Rosston, Mosgrove, Templeton, and Parkers Landing, Armstrong Co.; Walnut Bend, Venango Co.; Tionesta and Hickory, Forest Co.; Warren, Warren Co.

Conemaugh River, New Florence, Westmoreland Co.
Loyalhanna River, Idlepark, Westmoreland Co. (D. A. Atkinson).
Crooked Creek, Rosston, Armstrong Co.
French Creek, Utica, Venango Co.; Cochranton, Meadville, and Cambridge Springs, Crawford Co.
Connewango Creek, Russell, Warren Co.

*Monongahela-drainage:*

Monongahela River, Charleroi, Washington Co. (G. A. Ehrmann).
Youghiogeny River, Boston, Allegheny Co. (D. A. Atkinson).
Cheat River, Cheat Haven, Fayette Co.

*Other localities represented in the Carnegie Museum:*

*Lake-drainage:*

Grand River, Cayuga, Haldimand Co., Ontario, Canada (C. Goodrich).
Sandusky River, Fremont, Sandusky Co., Ohio (C. Goodrich).
Maumee River, Defiance, Defiance Co., Ohio (C. Goodrich).
Raisin River, Monroe and Grape P. O., Monroe Co., Michigan (C. Goodrich).
Huron River, Newport, Monroe Co., Michigan (C. Goodrich).
Grand Rapids, Kent Co., Michigan (Hartman collection).

*Ohio-drainage:*

Ohio River, Congo, Hancock Co., West Virginia; Toronto, Jefferson Co., Ohio; St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.
Tuscarawas River, Ohio (Holland collection).
West Fork White River, Riverside, Green Co., Indiana (J. D. Haseman).
Little Kanawha River, Grantsville, Calhoun Co., West Virginia (W. F. Graham).
Elk River, Shelton and Clay, Clay Co.; Gassaway, Braxton Co., West Virginia.
Levisa Fork Big Sandy River, Prestonsburg, Floyd Co., Kentucky.
Licking River, Farmer, Rowan Co., Kentucky.

*Mississippi and westward:*

Kishwaukee River, Rockford, Winnebago Co., Illinois (P. E. Nordgren).
Mississippi River, Muscatine, Muscatine Co., Iowa (Hartman collection).
Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).[148]

*Distribution and Ecology in Pennsylvania* (See fig. 24): A very common species in western Pennsylvania, but restricted to the larger streams and some of the larger tributaries. In the Ohio, Allegheny, and Monongahela, it is (or was) everywhere present, but in the two latter only up to a certain point. In the Allegheny it goes up to Warren, and beyond, at least as far as Olean, Cattaraugus Co., New York (Marshall, 1895), but is not found in the uppermost part in McKean Co., Pennsylvania. In the Monongahela it has been found as high up as the Cheat,

[148] Mostly normal; but one specimen agrees with one of the Arkansas forms, with dark bold rays, and pink nacre.

but I never have seen it in the upper Monongahela (West Fork River) in West Virginia. Likewise in the tributaries, it only goes up for a certain distance, and then rather suddenly stops. This is the more remarkable, since it is, where present, the prevailing species, outnumbering all other species combined, and then disappears entirely sometimes within a few miles. In the Little Beaver I have never seen it above Cannelton. It is plentiful at Edinburg in the Mahoning, but at Hillsville, a few miles farther up, I saw only a single dead shell, and it is absent

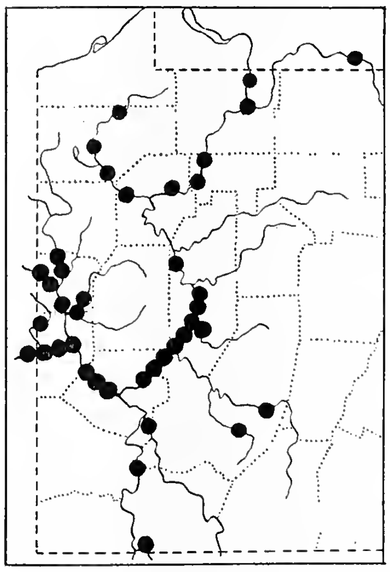

Fig. 24.
● *Actinonaias ligamentina.*

in the Ohio part of this river (Dean, 1890). It is plentiful at Pulaski in the Shenango, but above Sharon there is no trace of it. It goes into the Connoquenessing to Ellwood City, and enters the mouth of Slipperyrock Creek, but is not found farther up. It used to be found in the Kiskiminetas, but our material from this stream is scanty. A dead shell was found in the Loyalhanna at Idlepark. In Crooked Creek it occurs only at the mouth; in French Creek it extends up to Cambridge Springs, and in Connewango Creek as far up as Russell.

Thus it is clear that *A. ligamentina* prefers the larger rivers. It is found here in various environmental conditions, but is apparently best fitted for rough parts, riffles with strong currents and heavy gravel and rocks. Baker (1898*a*) says that it is found in muddy and sluggish rivers in soft mud, but this is decidedly not the case in our region. Call (1900) also calls it a "mud-loving species." In the Ohio below Pittsburgh and far down toward Cincinnati it is the form mainly composing the shell-banks.

*General distribution: Type locality,* Ohio River (Lamarck).

That this species favors the larger rivers seems to hold good throughout the rest of its range, as well as in Pennsylvania. It is found nevertheless in the northern tributaries of the Ohio in Ohio, Indiana, and Illinois. In this region, it had a chance to cross over into the lake-drainage, and is present in the Cuyahoga River in Ohio (Dean, 1890, Dall & Simpson, 1895), in the Maumee-drainage in Ohio and Indiana (Call, 1896*a*), and in the tributaries of Lake Michigan in Indiana (Call) (See also our material). It is not found in the Michigan-drainage in Illinois, although it ascends in the Desplaines River into the Chicago area (Baker, 1898*a*). It occurs also in the southern part of Michigan (Walker, 1898) in the Lake Erie-drainage, but is not in Lake Erie proper, and not in the lower St. Lawrence-drainage.[149] From Illinois it goes northward into Wisconsin (occurring also in the lake-drainage at Racine, Racine Co., according to Call (1885) and Milwaukee, according to Lapham (1860) and Minnesota (Call, 1885; Grant, 1886; Holzinger, 1888) and here apparently crossing over into the northern drainage in Manitoba (Simpson, 1900) reported from Roseau River by Dawson (1875). Call (1895) mentions it from Dakota, but the particulars are not known. It certainly occurs in Iowa, disregarding the Mississippi (See Call, 1895; Marshall, 1895; Geiser, 1910), and the eastern part of Kansas (Scammon, 1906).

It is also found present south of this range and is known from the southern tributaries of the Ohio in West Virginia and eastern Kentucky, from which specimens are before me. It is commonly reported from the Cumberland and Tennessee-drainages, but here the var. *gibba* turns up, and particulars as to the mutual relation of the distribution of the two varieties are lacking. All the material, without exception, which I collected in the upper Tennessee region in Tennessee and Virginia represents the form *gibba*. Wilson & Clark (1914) say that in the Cumberland River "chiefly the southern mucket" (*gibba*) is found.

From Missouri southward into Arkansas *ligamentina*-forms exist, and *ligamentina* has been reported from Missouri, for instance, by Utterback (1916) and by Wheeler (1918) from the Ouachita in Arkansas. But, as has been stated, different races (at least two of them) are found here, and these require further study. In the Alabama-drainage, this type of Naiad seems to be entirely missing.

[149] Simpson's record from Ontario (1900) is vague, but the Carnegie Museum has it from Ontario north of Lake Erie (Grand River).

## Genus Amygdalonaias Crosse & Fischer (1893).

Ortmann, 1912, p. 327; Simpson, 1914, p. 306 (as subgenus of *Plagiola*).

Type *Unio cognatus* Lea.

The nomenclature of this genus must remain provisional, until we know the anatomical structure of the type-species. Two species have been reported from Pennsylvania.

Key to the Species of Amygdalonaias.

$a_1$. Shell short and high, larger. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *A. truncata.*
$a_2$. Shell elongated and low, smaller. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *A. donaciformis.*

## Amygdalonaias truncata (Rafinesque) (1820).

*Plagiola elegans* (Lea) Simpson, 1914, p. 307; *Amygdalonaias truncata* (Rafinesque) Utterback, 1916, p. 148.[150]

Plate XIV, fig. 7.

*Records from Pennsylvania:*

Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co.).
Ortmann, 1909*b*, p. 192.

*Characters of the shell:* Shell rather small, moderately thick. Outline subtriangular-ovate, short and high. Anterior margin rounded, curving into the lower margin, the latter nearly straight posteriorly, and often somewhat concave. Upper margin short, curved, passing in a blunt angle or insensibly into the obliquely descending posterior margin, which joins the lower margin in a more or less distinct angle, so that the posterior end of the shell appears pointed. Beaks more or less elevated, somewhat incurved, situated somewhat in front of the middle. Beak-sculpture rudimentary, consisting of three or four fine bars, the first subconcentric, those following double-looped; the posterior loop is triangularly pointed, and its ascending part on the posterior slope is obsolete. Valves convex, more strongly so in the anterior part of the shell, flattened upon the sides, and often with a faint depression in front of the posterior ridge. The latter is distinct, often elevated and keel-like towards the beaks. The posterior slope appears truncate, slightly convex, flat, or even slightly concave.

Epidermis yellowish brown or greenish, mostly with well-developed rays. Rays wide or narrow, straight. Very often there is a pattern of dark spots upon the rays, which may be arrow-shaped, or wavy, and may extend over a large part

[150] Vanatta (1915, p. 553) does not accept Rafinesque's specific name on account of *Unio truncata* Spengler (1793); however, this does not conflict, since Rafinesque called his species *Truncilla truncata.* See also Walker, 1916, p. 45.

of the surface. In older specimens the color-markings often become obscure, and the epidermis is uniformly brown or blackish.

Hinge well-developed. Pseudocardinals two in left, one or two in right valve, triangular, elevated and compressed, ragged. Interdentum quite narrow and short. Laterals moderately long. Beak-cavity moderate. Dorsal muscle-scars in beak-cavity. Anterior adductor-scars distinct and well impressed, posterior ones faint. Nacre silvery white, rarely pinkish.

Sexual differences in the shell very indistinct. Specimens with a more distinct furrow in front of the posterior ridge, and with the posterior section of the lower margin concave, are generally males; while the opposite condition indicates the female sex. In most cases it is very hard to determine the sex from the shell.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Neville Island, Cat. No. 61.1761 | 58 mm. | 43 mm. | 27 mm. |
| 2. Industry, Cat. No. 61.3569 (♂) | 51 " | 40 " | 23 " |
| 3. do. Cat. No. 61.3570 (♂) | 46 " | 36 " | 22 " |

No. 1 is one of the largest specimens at hand. No. 2 might be a female according to the shape of the shell, but the soft parts had the male structure.

*Soft parts* (See Ortmann, 1912, p. 328). *Glochidia:* Lefevre & Curtis (1910, p. 97, fig. 1; 1912, p. 146, fig. 3); Surber (1912, Pl. 2, fig. 30). They are very small: $0.075 \times 0.09$ mm.

*Breeding season:* I found only one gravid female, with glochidia, on May 25, 1914. Lefevre & Curtis (1912, p. 141) list this species with the bradytictic forms. Surber (1912, p. 6) states that gravid females with glochidia were found in May and July.

*Remarks:* The species is easily recognized by its subtriangular shape, its sharp posterior ridge, truncate posterior slope, and the peculiar color-pattern of the epidermis. It only resembles the following species, but is distinguished from that by the higher and shorter shell, which also grows to a larger size. In addition this species has a certain resemblance to the male of *Truncilla triquetra* both in general shape as well as in color. However *Truncilla triquetra* is a more elongated shell, the posterior slope is broader, and more distinctly truncate, and the shell is more inflated.

The posterior ridge of *A. truncata* is quite variable. In Pennsylvania it is not so sharp as elsewhere. From Louisiana, for instance, I have specimens in which it is keel-like. The form from Lake Erie is smaller and lighter, but very variable in color. Having not been found on the Pennsylvanian shores of the lake, I shall not here discuss this form.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Ohio River, Shippingport and Industry, Beaver Co.; Neville Island, Allegheny Co.

*Other localities represented in the Carnegie Museum:*

*Lake-drainage:*

Lake Erie, Vermilion, Erie Co., Ohio; La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).
Sandusky River, Fremont, Sandusky Co., Ohio (C. Goodrich).
Maumee and Erie Canal, Lucas Co., Ohio (C. Goodrich).

*Ohio-drainage:*

Ohio River, Toronto, Jefferson Co., Ohio; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio.
West Fork White River, Riverside, Greene Co., Indiana (J. D. Haseman).
Wabash River, New Harmony, Posey Co., Indiana (A. A. Hinkley).
Levisa Fork Big Sandy River, Prestonsburg, Floyd Co., Kentucky.

*Tennessee-drainage:*

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).
Bear Creek, Burleson, Franklin Co., Alabama (H. H. Smith).
Paint Rock River, Paint Rock, Jackson Co., Alabama (H. H. Smith).
Holston River, Hodges, Jefferson Co., Tennessee.
Clinch River, Solway, Knox Co.; Edgemoor and Clinton, Anderson Co.; Black Fox Ford, Union Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee.

*West of Mississippi:*

Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).
Marais des Cygnes River, Richhill, Bates Co., Missouri (W. I. Utterback).
James River, Galena, Stone Co., Missouri (A. A. Hinkley).
White River, Cotter, Baxter Co., Arkansas (A. A. Hinkley).
Black River (H. E. Wheeler) and Spring River (A. A. Hinkley), Black Rock, Lawrence Co., Arkansas.
Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).
Verdigris River, Wagoner, Wagoner Co., Oklahoma (F. B. Isely).
Bayou Pierre, De Soto Par., Louisiana (L. S. Frierson).

*Distribution and Ecology* (See fig. 25): *Type locality*, Ohio River (Rafinesque) (Vanatta says "Falls of the Ohio").

In Pennsylvania this species is rare, and turns up only in the Ohio below Pittsburgh. The few specimens I found there, were found in and below riffles, probably washed out of shells-banks above them.

According to Simpson (1900) this form is generally found in the Mississippi-drainage, but crosses over into the lake-drainage in southern Michigan, Lake Michigan, and Lake Erie (Sterki, 1907*a*, Walker, 1913, and our localities). However it has not been found on the Pennsylvanian shores of Lake Erie.[151] In Ohio

[151] Call (1885) mentions it from western New York which extreme eastern extension might refer to Lake Erie. Marshall (1895) quotes it from Buffalo, but from an entirely unreliable source.

it is also occurs in tributaries to the lake, the Maumee, Tiffin, and Sandusky Rivers (See Sterki). It is found in the Ohio-drainage in Ohio (Sterki), Indiana (Call, 1896*a*, 1900). It is widely distributed in Illinois (Baker, 1906). In the Mississippi, it ascends from Illinois and Iowa to Wisconsin (Lapham, 1860) and as far as Minnesota (Grant, 1886; Holzinger, 1888). It extends down the Mississippi and

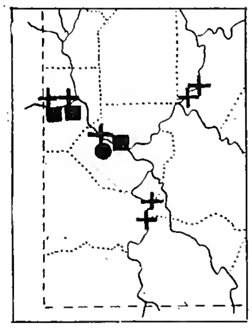

FIG. 25.

■ *Amygdalonaias truncata.*
● *Amygdalonaias donaciformis.*
+ *Plagiola lineolata.*

to its western tributaries from Missouri (Utterback, 1916) to eastern Kansas (Scammon, 1906), Arkansas (Call, 1895; Wheeler, 1918), Oklahoma (Carnegie Museum), and western Louisiana (Frierson, 1899; Vaughan, 1893), and is found in eastern Texas (Singley, 1893) and as far as Trinity River (Simpson). From the southern tributaries of the Ohio records are scarce, but it is known from the Big Sandy in Kentucky, from the Cumberland (Wilson & Clark, 1914), from Duck River in Tennessee (Marshall, 1895), and from the Tennessee and its tributaries in Alabama up to the Holston and Clinch in eastern Tennessee.

Lewis (1877) cites it from the Alabama-drainage, but this has never been confirmed.

### AMYGDALONAIAS DONACIFORMIS (Lea) (1828).

*Plagiola donaciformis* (LEA) SIMPSON, 1914, p. 308.

Plate XIV, figs. 8, 9.

*Records from Pennsylvania:*

Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co.).

*Characters of the shell:* Shell much like that of *A. truncata*, but distinguished by the general shape, which is more elongated and less elevated. The posterior ridge, although well marked toward the beaks, is not so sharp as in *A. truncata*, and there is no depression in front of it. Color-markings of the epidermis of the

same general character, but the arrow-shaped spots are more prominent, and often extend over large parts of the shell in a zig-zag pattern.

Male and female shells a little more distinct. In the male the posterior part of the lower margin slopes up in a nearly straight line, rendering the posterior end of the shell more sharply pointed, while in the female the lower margin is more expanded and curved, making the posterior end more bluntly pointed. But there are cases in which the difference is hardly noticeable. Sometimes in the female the posterior part of the lower margin behind the expansion is slightly concave.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. (No-locality) Cat. No. 61.787 (probably ♂)..... | 49 mm. | 34 mm. | 20 mm. |
| 2. do. " " do. (probably ♀) ..... | 41 " | 26 " | 18 " |

*Soft parts* described, but rather unsatisfactorily, by Simpson in (Baker, 1898, p. 91). I find that the soft parts agree completely with those of *A. truncata*. *Glochidia* (See Surber, 1912, Pl. 2, fig. 29; and Ortmann, 1914, p. 67). They also are remarkable for their small size. Surber's dimensions are: 0.060 × 0.063 mm.; mine are: 0.05 × 0.06 mm.

*Breeding season:* Surber found eggs and glochidia in July. I received specimens with glochidia collected on Aug. 18, 1912.

*Remarks:* This species is closely allied to *A. truncata,* and possibly may be only a variety of it. But, as far as I can see, there are no intergrades between them.

This is the only species previously reported from western Pennsylvania, which I have not collected myself. I have seen the specimens collected by Rhoads (now in the Philadelphia Academy), and thus it is beyond doubt that it once existed in our state. It may yet be found on the Pennsylvanian shores of Lake Erie.

*Localities represented in the Carnegie Museum:*

*Lake-drainage:*

Lake Erie, Vermilion (C. Goodrich) and Cedar Point (O. E. Jennings), Erie Co., Ohio; La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).

Miami and Erie Canal, Lucas Co., Ohio (C. Goodrich).

*Ohio-drainage:*

Ohio River, Parkersburg, Wood Co., West Virginia.

West Fork White River, Riverside, Greene Co., Indiana (J. D. Haseman).

Wabash River, New Harmony, Posey Co., Indiana (A. A. Hinkley).

*Tennessee-drainage:*

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).

*Mississippi River and westward:*

Mississippi River, Moline, Rock Island Co., Illinois (P. E. Nordgren).

Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).
Hinkston Creek, Columbia, Boone Co., Missouri (D. K. Greger).
Missouri River, St. Joseph, Buchanan Co., Missouri (W. I. Utterback).
Black River, Black Rock, Lawrence Co., Arkansas (H. E. Wheeler).
Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).

*Alabama-drainage:*

Coosa River, Weduska Shoals, Shelby Co.; Riddles Bend, Cherokee Co., Alabama (H. H. Smith).

*Distribution and Ecology* (See fig. 25): *Type locality,* Ohio (Lea).

In Pennsylvania this species has been found only in the Ohio in Allegheny County. It seems to cover about the same range as *A. truncata* (See Simpson, 1900). It goes from Lake Erie down the Ohio, and its tributaries, and up the Mississippi to Minnesota, and westward and southward down and across the Mississippi to Kansas, Oklahoma, and eastern Texas. But in addition it has been reported from Alabama (Simpson) and Coosa River (Call, 1885), and its presence in the latter river is confirmed by specimens in the Carnegie Museum.

It has been referred to as a mud-loving shell by Baker (1898), and as an inhabitant of sand-bars by Call (1900), and of the sandy and muddy beds of rivers, avoiding smaller streams, by Scammon (1906).

### Genus PLAGIOLA Rafinesque (1820).[152]

Ortmann, 1912, p. 329; Simpson, 1914, p. 302.

Type *Obliquaria lineolata* Rafinesque.

Monotypic genus.

### PLAGIOLA LINEOLATA (Rafinesque) (1820).

*Plagiola securis* (LEA) SIMPSON, 1914, p. 304; *Plagiola lineolata* (RAFINESQUE) VANATTA, 1915, p. 553.[153]

Plate XIV, fig. 10, Plate XV, figs. 1, 2, 3.

*Records from Pennsylvania:*

Harn, 1891 (western Pennsylvania).
Clapp, 1895 (Allegheny Co.).
Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co.).
Ortmann, 1909*b*, p. 192.

*Characters of the shell:* Shell rather large, heavy and solid. Outline triangularly-ovate, generally slightly longer than high. Anterior margin rounded, curving into the lower margin, which is less convex, or nearly straight in its posterior part.

[152] Not 1819. It was published in 1819 as "*nomen nudum.*"
[153] See also Walker, 1916, p. 45.

Upper margin short, convex, continued without any angle into the obliquely descending posterior margin, which meets the lower margin in a distinct, but rounded, lower posterior angle. Beaks moderately elevated above the hinge-line, incurved, located in front of the middle of the shell. Beak-sculpture obscure, consisting of two or three fine and faint, double-looped bars. Valves rather compressed, moderately convex anteriorly, much more flattened on the sides, and peculiarly compressed towards the beaks. Posterior ridge very distinct, although rounded, sharpest towards the beaks. Posterior slope, behind the ridge, narrow, truncate, flat, almost concave towards the beaks, but slightly convex towards the posterior end.

Epidermis greenish yellow to light brown, darker in old individuals, with more or less distinct rays, which are rather narrow, dark brown or dark green, and are generally broken into lunate or squarish, dark spots. In old specimens, the rays may become indistinct, but traces of them and of the spots on them, are in most cases preserved at least in part of the shell.

Hinge well-developed and heavy. Pseudocardinals two in left, one or two in right valve, heavy, ragged. Interdentum well-developed, rather wide and flat. Laterals heavy. Beak-cavity moderate. Dorsal muscle-scars partly in the beak-cavity, partly upon the hinge-plate. Adductor-scars well-developed and rather deep, chiefly the anterior ones. Nacre whitish.

Sexual differences of shell not very great, but generally well-marked. The female shell remains considerably smaller than that of the male, is more inflated, so that the posterior ridge is not so sharp, but there is hardly a difference in the outline, except that the posterior end is more rounded.[154]

| | | L. | H. | D. |
|---|---|---|---|---|
| *Size:* (Males) | 1. Cooks Ferry, Cat. No. 61.3565 | 118 mm. | 91 mm. | 51 mm. |
| | 2. do. " " do. | 107 " | 83 " | 49 " |
| | 3. do. " " 61.4421 | 94 " | 74 " | 38 " |
| (Females) | 4. Cooks Ferry, Cat. No. 61.3565 (gravid) | 84 " | 63 " | 40 " |
| | 5. do. " " do. (gravid) | 80 " | 62 " | 38 " |
| | 6. Industry, Cat. No. 61.3568 (gravid) | 70 " | 59 " | 37 " |

The above measurements include the maximum records for either sex.

*Soft parts* (See Ortmann, 1912, p. 329). *Glochidia* (Lea, Obs. VI, 1858, Pl. 5, fig. 8; Lefevre & Curtis, 1910, p. 97, fig. H, and 1912, p. 146, fig. H; Ortmann, 1911*b*, Pl. 89, fig. 17; Surber, 1912, Pl. 2, fig. 14). My (maximum) measurements

[154] Simpson (1900, p. 603) says that the female shell is swollen at the postbasal region. This is hardly correct. The swelling of the female is noticeable chiefly over the lateral faces of the disk, but very rarely in the postbasal region.

are: 0.26 × 0.35 mm.; those of Lefevre & Curtis, 0.23 × 0.31; those of Surber: 0.230 × 0.330.

*Breeding season:* I have the following dates for gravid females: Sept. 10, 1908; Sept. 12, 1908; Sept. 23, 1908; Sept. 24, 1910; Sept. 25, 1908; Oct. 3, 1908; Nov. 4, 1914; Nov. 17, 1917. Furthermore: Febr. 6, 1911; June 14, 1911; June 20, 1911; June 21, 1911; July 13, 1911. In every case glochidia were present, and on the three days in June, discharging females were present. On July 13 only a single individual, having almost entirely discharged the glochidia, was found. Thus the species is clearly *bradytictic*, and the breeding season probably begins in August and lasts till June or July of the next year. The interim would include part of July and August. Surber's observations agree with this.

*Remarks:* This species is easily recognized and not liable to be confounded with any other. The subtriangular, compressed shape, with a narrow posterior truncation, and the peculiar color-pattern, are very distinctive characters. The females are quite variable in shape and the compression of the shell is not so striking.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Ohio River, Smiths Ferry (W. F. Graham), Cooks Ferry, Shippingport, and Industry Beaver Co.; and Neville Island, Allegheny Co. (W. F. Graham).

Allegheny River, Godfrey and Kelly, Armstrong Co.

Monongahela River, Westmoreland Co., and Charleroi, Washington Co. (G. A. Ehrmann).

*Other localities represented in the Carnegie Museum:*

*Ohio-drainage:*

Ohio River, Toronto, Jefferson Co., Ohio; Beach Bottom, Brook Co., West Virginia (W. F. Graham); Clarington, Monroe Co., Ohio; St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.

*Cumberland- and Tennessee-drainages:*

Cumberland River, Burnside, Pulaski Co., Kentucky (B. Walker, donor).

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith); Knoxville and Brabsons Ferry, Knox Co., Tennessee.

Paint Rock River, Paint Rock, Jackson Co., Alabama (H. H. Smith).

Clinch River, Offutt, Anderson Co., Tennessee.

*Mississippi river and westward:*

Mississippi River, Muscatine, Muscatine Co., Iowa (Hartman collection).

Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).

Neosho River, Burlington, Coffey Co., Kansas (R. L. Moodie); Miami, Ottawa Co., Oklahoma (F. B. Isely).

White River, Cotter and Norfolk, Baxter Co., Arkansas (A. A. Hinkley).

Black River, Black Rock, Lawrence Co., Arkansas (H. E. Wheeler).

Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).

*Alabama-drainage:*

Coosa River, Wetumpka, Elmore Co.; Weduska Shoals and Wilsonville, Shelby Co.; Riverside and Lock 4, St. Clair Co.; Minnesota Bend, Cherokee Co., Alabama (H. H. Smith).

*Distribution and Ecology in Pennsylvania* (See fig. 25): In Pennsylvania this species is found only in the Ohio, Allegheny, and Monongahela. In the Allegheny it goes to southern Armstrong County, where it is quite rare. In the Monongahela it is known only from Charleroi in Washington County, and on the opposite side in Westmoreland County. Below Pittsburgh it is not a rare shell, and has been found in considerable numbers in the riffles and the shell-banks in coarser or finer gravel and in strong currents.

Farther down the Ohio this is a common shell in the shell-banks, and is regularly taken by the clam-diggers.

*General distribution: Type locality,* Falls of the Ohio, at Louisville, Kentucky (Rafinesque).

This species primarily belongs to the large rivers of the interior basin. In the Ohio its extreme upstream range reaches Pennsylvania. Farther down it is mainly restricted to this river (Sterki, 1907*a*). In Indiana it also occurs in the larger tributaries, the Wabash and West White Rivers (Call, 1896*a*, 1900) and has crossed over, probably very recently, into the Maumee at Fort Wayne, Indiana (Goodrich, 1914). This is the only known record from the lake-drainage. In Illinois it is also found in the Wabash, Kaskaskia, and Illinois Rivers, in the latter as high up as Peoria County (Forbes & Richardson, 1913), and to the Kankakee (Baker, 1906). It ascends the Mississippi as far as Minnesota (Grant, 1886; Holzinger, 1888). It is also found in the Cumberland River (Wilson & Clark, 1912*b* and 1914) and in the Tennessee it goes up according to Lewis (1871) to the "Holston" near Knoxville, but it must be born in mind that the "Holston" of Lewis is the Tennessee. I found it there myself and also in the lower Clinch in Anderson County, but not in the Holston proper.

West of the Mississippi this species is found in Missouri (Utterback, 1916) in southeastern Kansas (Scammon, 1906), Arkansas and Oklahoma (See Call, 1895; Wheeler, 1918; and the material in the Carnegie Museum) but its exact southwestern boundary has not been determined.

In addition it is present in the Alabama and Tombigbee drainages in Alabama (Lewis, 1877; Call, 1885; Simpson, 1900; and material in Carnegie Museum) and has reached Georgia in the Etowah River (Call, 1885).

Everywhere it seems to favor the "mussel-beds" in the larger rivers. Scammon (1906) reports it from rocky riffles in Kansas, but says that it occurs in a

variety of locations, and Call (1900) says that it is found on sand, gravel, and mud-bars, but preferably on the last.

### Genus Paraptera Ortmann (1911).

Ortmann, 1912, p. 330.[155]

Type *Unio fragilis* Rafinesque.

Only the type-species is positively known to belong to this genus, although it is probable that several others go with it. The type has been found in our state.

### Paraptera fragilis (Rafinesque) (1820).

*Lampsilis gracilis* (Barnes) Simpson, 1914, p. 181; *Lampsilis fragilis* (Rafinesque) Vanatta, 1915, p. 552; *Lasmonos fragilis* (Rafinesque) Utterback, 1916, p. 152.

Plate XV, figs. 4, 5. 6.

*Records from Pennsylvania:*

Clapp, 1895 (Allegheny Co.)
Marshall, 1895 (Allegheny River, Warren Co.)[156]
Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co.)
Ortmann, 1909*b*, pp. 192 and 202.

*Characters of the shell:* Shell large, but thin. Outline subovate or subelliptical, normally with a high posterior wing, which renders the outline subtriangular. However, this wing may be obliterated, chiefly in old shells. There is also generally a small anterior wing. Shell more or less symphynote at the wings. Anterior margin rounded, united with the upper margin in a sharp angle. Lower margin more or less regularly curved. Upper margin straight, elevated posteriorly, forming the posterior wing and angle. Posterior margin obliquely descending, sometimes somewhat concave just below the upper posterior angle, joining the lower margin in a broad curve, so that there is no posterior angle. Beaks low, hardly elevated above the hinge-line, located in the anterior portion of the shell. Beak-sculpture faintly developed, rudimentary, consisting of three or four fine bars, the first of which is subconcentric, the others double-looped, but only with the

[155] Utterback (1916, p. 151) uses for this genus, the name of *Lasmonos* Rafinesque (1831). However, the type of *Lasmonos* (*L. fragilis* Rafinesque, 1831) is not *Unio fragilis* Rafinesque (1820), but *Unio leptodon* Rafinesque (1820), for which Rafinesque proposed the subgenus *Leptodea* in 1820. Thus *Lasmonos* is a synonym of *Leptodea*. If *U. leptodon* should prove to be congeneric with *Paraptera fragilis*, then, of course, my *Paraptera* should give way, not to *Lasmonos*, but to *Leptodea*.

[156] I doubt the correctness of this locality. In the Allegheny I found this species as far up as southern Armstrong County, where it is very rare. No trace of it was seen above Oil City.

posterior loop distinct, while the anterior is obliterated. Valves rather compressed, moderately and rather uniformly convex, slightly more flattened upon the sides. No distinct posterior ridge. Posterior slope compressed, and even somewhat excavated, chiefly when the upper posterior wing is well developed.

Epidermis smooth, light-colored, pale yellowish to pale greenish, sometimes light olive-brown, with or without greenish rays. When present, the rays are straight, continuous, greenish, rather narrow, and not well-defined. On the posterior slope, the epidermis is lamellar, darker, often with indications of a few stronger rays. Growth-rests generally distinctly indicated by dark concentric bands.

Hinge poorly developed. Pseudocardinals two in left, one in right valve, feeble, subtriangular and lamellar, compressed, often imperfect and represented by mere ridges. Interdentum absent. Laterals long and thin, the lower one in left valve often rudimentary. Beak-cavity shallow. Dorsal muscle-scars in an oblique row in the beak cavity, but rather far from its extreme point. Adductor-scars faintly impressed, the anterior ones more distinct than the posterior ones. Nacre silvery white, in most cases with more or less pink, chiefly towards the beak-cavity; sometimes entirely pinkish.

Sexual differences distinctly marked in the shell. In the male the lower margin is regularly convex, curving up in its posterior half, and the posterior end of the shell is rather narrowly rounded. In the female the lower margin is more expanded in the postbasal region, so that a greater anterior section is descending, while posteriorly it curves up in a very broad curve, rendering the posterior end of the shell more broadly rounded. In the male the greatest height of the shell is located more in the middle of the shell, in the female, it lies in its posterior portion. The posterior expansion of the female is generally extremely thin.

| | | L. | H. | D. |
|---|---|---|---|---|
| *Size:* (Males) | 1. Erie, Cat. No. 61.4807 | 116 mm. | 78 mm. | 38 mm. |
| | 2. Industry, Cat. No. 61.3549 | 100 " | 62 " | 33 " |
| | 3. Erie, Cat. No. 61.4808 | 99 " | 64 " | 32 " |
| | 4. Industry, Cat. No. 3549 | 67 " | 42 " | 21 " |
| (Females) | 5. Erie, Cat. No. 61.4109 | 100 " | 78 " | 32 " |
| | 6. do. Cat. No. 61.4807 (gravid) | 84 " | 65 " | 29 " |
| | 7. Edgeworth, Cat. No. 61.1360 | 82 " | 55 " | 23 " |
| | 8. Industry, Cat. No. 61.3549 (gravid) | 67 " | 46 " | 21 " |

The largest specimens at hand both from Lake Erie and the Ohio system are given. This species does not reach its maximum size in Pennsylvania, and, as is shown above, the specimens in Lake Erie are larger than those from the Ohio.

*Soft parts* (See Ortmann, 1912, p. 331). *Glochidia* (See Lefevre & Curtis, 1910, p. 97, fig. K, and 1912, p. 146, fig. K; Ortmann, 1911*b*, Pl. 89, fig. 19; Coker & Surber, 1911, Pl. 1, fig. 2; Surber, 1912, Pl. 2, fig. 28). My measurements are: $0.08 \times 0.09$; those of Lefevre & Curtis: $0.07 \times 0.09$; those of Surber: $0.070 \times 0.095$ mm.

*Breeding season:* I have the following records for gravid females: Aug. 30, 1909 (beginning to have eggs); Sept. 8, 1908; Sept. 10, 1908; Sept. 11, 1913; Sept. 17, 1913; Sept. 22, 1910; Sept. 25, 1908; Oct. 5, 1909. Then again in spring: May 9, 1913; May 19, 1911; May 22, 1909; May 24, 1911; May 25, 1914; July 7, 1910; July 8, 1910; July 11, 1909. This is a *bradytictic* form, the breeding season beginning in September. A specimen partly charged with eggs was found as early as August 30. Toward the end of September glochidia are found, but eggs have been observed as late as October 5. In spring, in May, glochidia are present, and discharge has been observed on May 22 (in Lake Erie). In the beginning of July the same has been found to be the case, and the latest date for a discharging female, July 11, refers to a specimen from the Ohio River. Thus part of July and August should be regarded as the "interim." There does not seem to be any difference between Lake Erie and the Ohio-drainage.

Surber found glochidia in October, November, January, June, July, and August, and thus it appears that under certain conditions the seasons may overlap in August.

*Remarks:* A species easily recognized by its subovate, compressed shape and high posterior wing, and, if the latter is reduced, by its yellowish color, thin shell, generally pink nacre, and weak or imperfect hinge-teeth. With regard to the development of the wings there is great variability. Young specimens generally have a well-developed, elevated, posterior wing, and a small anterior wing. But in old specimens the wings may become lower, and are sometimes absent (in many cases evidently broken off). This is chiefly true of specimens from the rivers (Ohio), while the shells from Lake Erie preserve the wings better, even in large individuals. This is undoubtedly due to the environment. The outline of the shell varies greatly with the absence or presence of the wings being more regularly elliptical, or subovate, or even subtriangular. There is also great variability in the hinge, the pseudocardinals being sometimes distinct, sometimes very poorly developed, knob-like, or like low ridges.

Contrary to what has been noted in other cases, the form from Lake Erie is larger and finer than the Ohio form. This is undoubtedly due to the fact, that the river-environment, as developed in western Pennsylvania, is not favorable to this

species, while the lake-environment suits it better. Otherwise there is no difference between the two forms, except that the form from the Ohio river has on the average a somewhat thicker shell and that the lake-form has a stronger tendency to pre-

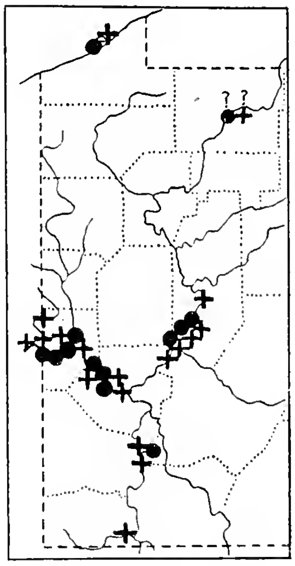


FIG. 26.

● *Paraptera fragilis.*
+ *Proptera alata.*

serve the wings in old shells. But all these peculiarities due to environment are more or less inconstant.

*Localities in Pennsylvania, represented in the Carnegie Museum:*

Ohio River, Smiths Ferry, Cooks Ferry, Industry, and Beaver, Beaver Co.; Dead Man's Island (Q. T. Shafer, A. T. Shafer, R. Foerster), and Edgeworth (G. H. Clapp), Allegheny Co.

Allegheny River, Aladdin, Godfrey, and Kelly, Armstrong Co.

Monongahela River, Westmoreland Co. (G. A. Ehrmann).

Lake Erie, Presque Isle Bay, Erie, Erie Co.

*Other localities represented in the Carnegie Museum:*

*Lake-drainage:*

Lake Erie, Vermilion (C. Goodrich) and Cedar Point (C. Brookover), Erie Co., Ohio; La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).

*Ohio-drainage:*

Ohio River, Toronto, Jefferson Co., Ohio; Wheeling, Ohio Co., West Virginia (W. F. Graham); St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.

West Fork White River, Riverside, Greene Co., Indiana (J. D. Haseman).

Little Kanawha River, Burnsville, Braxton Co., West Virginia.

Pocatalico River, Raymond City, Putnam Co., West Virginia.

*Tennessee-drainage:*

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).
Shoals Creek, Lauderdale Co., Alabama (H. H. Smith).
Paint Rock River, Paint Rock, Jackson Co., Alabama (H. H. Smith).
Tennessee River, Knox Co., Tennessee (Smith collection).
Nolichucky River, Chunns Shoals, Hamblen Co., Tennessee.
Holston River, Mascot, Knox Co.; Hodges, Jefferson Co.; Turley Mill, Noeton, and Holston Station, Grainger Co., Tennessee.
Clinch River, Edgemoor, Anderson Co.; Clinch River Station, Claiborne Co., Tennessee.
Powell River, Combs, Claiborne Co., Tennessee.

*Mississippi River and westward:*

Mississippi River, Muscatine, Muscatine Co., Iowa (Hartman collection); Moline, Rock Island Co., Illinois (P. E. Nordgren).
Hinkston Creek, Columbia, Boone Co., Missouri (D. K. Greger).
Kansas River, Lawrence, Douglas Co., Kansas (R. L. Moodie).
Black River, Black Rock, Lawrence Co., Arkansas (H. E. Wheeler).
Spring River, Williford, Sharp Co., Arkansas (H. E. Wheeler).
Saline River, Benton, Saline Co., Arkansas (H. E. Wheeler).
Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).
North Fork Canadian River, Weleetka, Okfuskee Co., Oklahoma (F. B. Isely).
Bayou Pierre, De Soto Parish, Louisiana (L. S. Frierson).

*Alabama-drainage:*

Buttahatchee River, Hamilton, Marion Co., Alabama (H. H. Smith).
Black Warrior River, Tuscaloosa, Tuscaloosa Co.; Squaw Shoals, Jefferson Co., Alabama (H. H. Smith).
Valley Creek, Toadvine, Jefferson Co., Alabama (H. H. Smith).
Coosa River, Wetumpka, Elmore Co.; near Yellow-Leaf Creek, Chilton Co.; Weduska Shoals and Peckerwood Shoals, Shelby Co.; Coosa Valley and Riverside, St. Clair Co.; Minnesota Bend, Cherokee Co., Alabama (H. H. Smith).

*Distribution and Ecology in Pennsylvania* (See fig. 26): In Pennsylvania, this species has two ranges. On the one hand it belongs to the three large rivers, without, however, going into their tributaries. In the Allegheny it goes only as far as southern Armstrong Co., where it is very rare; in the Monongahela, it has been found only in Westmoreland Co. (opposite Charleroi). On the other hand *P. fragilis* occurs in Lake Erie, where it is rather abundant in Presque Isle Bay. Here it apparently finds most congenial conditions on the sandy shores in from one to three feet of water; but it also has been obtained by the sand-sucker from a depth of ten to fifteen feet.

In the Ohio and Allegheny I found this species chiefly in riffles. Here it is a lively shell, crawling around frequently, and with a speed unusual in other shells. The shells are here not very perfect, and often more or less injured or stunted.

*General distribution: Type locality,* Ohio River (Rafinesque) (Vanatta says: "creeks in Kentucky").

*P. fragilis* has an immense range, extending from central Texas (Singley, 1893) north to the Red River of the North, and east and northeast over the whole Mississippi and Ohio drainages, crossing over into the lake-drainage in Wisconsin, Ohio, and Michigan, and going down the St. Lawrence to the Ottawa River (Call, 1885). In this latter region it has extended also into Lake Champlain, and from western New York (Marshall, 1895) through the Erie canal has reached the Hudson River, thus entering the Atlantic watershed. In addition it is found in the Alabama and Tombigbee drainages in Mississippi and Alabama (Lea, Obs. X, 1863; Conrad, 1836; Marshall, 1895). The latter part of the range is not given by Simpson.

It is not necessary to mention particular localities, but the western and southwestern boundaries, and also the northern boundaries, are rather indefinitely known. The records from Kentucky and Tennessee were meagre hitherto, but the species is present in the Cumberland (Wilson & Clark, 1914) and I found it frequently in the upper Tennessee-drainage.

The ecological preferences of this species seem to be for large rivers and lakes, and it avoids smaller rivers and creeks. Its absence from the Tuscarawas River in Ohio, according to Sterki (1907*a*) and from the Beaver in Pennsylvania should be noted. Where I found it in small streams, it was generally in eddies and pools. But, as has been stated, it occurs also on riffles, but possibly it has been in such cases washed out of the deeper and more quiet pools. Previous authors have made similar observations (Call, 1895, 1900; Baker, 1898*a*; Scammon, 1906).

### Genus Proptera Rafinesque (1819).[157]

Ortmann, 1912, p. 332; Simpson, 1914, p. 161 (as subgenus of *Lampsilis*).

Type *Unio alata* Say.

Only one species in Pennsylvania.

### Proptera alata (Say) (1817).[158]

*Lampsilis alata* (Say) Simpson, 1914, p. 162.

Plate XV, fig. 7; Plate XVI, figs. 1, 2.

*Records from Pennsylvania:*

Harn, 1891 (western Pennsylvania).
Stupakoff, 1894 (Allegheny Co.).
? Marshall, 1895 (Allegheny River, Warren Co.).[159]

[157] This is the only one of the names proposed by Rafinesque in 1819, which has been properly defined. The alate character of the shell has been mentioned, and a type (*alata*) has been given.

[158] Not 1816.

[159] I have never seen a trace of this shell above Oil City, although it is not easily overlooked, and

Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co.).
Ortmann, 1909*b*, pp. 191 and 202.

*Characters of the shell:* Shell very large, moderately thick. Outline subovate, but generally with a high posterior wing, which makes the outline subtriangular. This wing is very variable, but rarely (in old shells) indistinct. Sometimes there is an indication of a small anterior wing. Shell symphynote at the wings. Anterior margin rounded. Lower margin slightly convex, or almost straight posteriorly. Upper margin straight, ascending posteriorly, and forming with the posterior margin, the elevated wing-like angle. Posterior margin obliquely descending, slightly concave just below the angle, or straight, and passing in a broad curve into the lower margin, so that there is no lower posterior angle to the shell. Beaks low, hardly elevated above the hinge-line, located in the anterior section of the shell. Beak-sculpture indistinct, feeble, consisting of three or four fine bars, the first subconcentric, the following ones double-looped, with the anterior loop almost effaced. Valves rather compressed, gently convex, flattened upon the sides; no posterior ridge, but shell in this region broadly rounded, with one or two fine radiating, elevated lines. Posterior slope compressed or slightly excavated, elevated into the posterior wing.

Epidermis thick, dark, in young specimens sometimes dark greenish, but generally dark brown to black, without any rays. Mere traces of rays are rarely visible in young specimens. Growth-rests are generally not marked by darker color.

Hinge well-developed. Pseudocardinals two in left, one or two in right valve, moderately thick, triangular, ragged. No interdentum. Laterals long, generally curved, moderately strong. Beak-cavity shallow. Dorsal muscle-scars in an irregular, almost vertical row in the beak-cavity. Adductor-scars distinct, the anterior impressed, the posterior less so.

Nacre always purple, generally very dark purple, rarely light purple, and in one case I have seen a pale salmon-color, whitish toward the margins of the shell.

Sexual differences present in the shell, but less marked than in *Paraptera fragilis*. The female is slightly more swollen in the posterior part of the shell, and the lower margin is more broadly rounded in the postbasal region. These differences, however, are slight, and not always reliable. Further, it seems that the female does not attain the extreme size of the male.

if no living shells are found, dead ones are very conspicuous. Its uppermost limit in the Allegheny is Templeton in Armstrong Co., and above Pittsburgh it is in the Allegheny altogether a rare shell.

| | | | L. | H. | D. |
|---|---|---|---|---|---|
| *Size:* | (*Ohio-form*) | 1. Wiley, Cat. No. 61.3537 (sex ?) | 165 mm. | 121 mm. | 57 mm. |
| | | 2. Godfrey, Cat. No. 61.4107 (♂) | 157 " | 112 " | 44 " |
| | | 3. Industry, Cat. No. 61.4416 (♂) | 118 " | 84 " | 33 " |
| | | 4. Industry, Cat. No. 61.3538 (♀ gravid) | 118 " | 79 " | 38 " |
| | | 5. Cooks Ferry, Cat. No. 61.3540 (♀ gravid) | 101 " | 78 " | 35 " |
| | (*Lake Erie-form*) | 6. Erie, Cat. No. 61.4102 (♀ gravid) | 91 " | 68 " | 36 " |
| | | 7. do. Cat. No. 61.3267 (♂) | 91 " | 65 " | 32 " |
| | | 8. do. Cat. No. 61.4816 (♀) | 87 " | 69 " | 31 " |
| | | 9. do. Cat. No. 61.4817 (♂) | 75 " | 58 " | 25 " |

*Soft parts* (See Ortmann, 1912, p. 333). *Glochidia:* Lea (Obs. VI, 1858, Pl. 5, fig. 25); Lefevre & Curtis, 1910, p. 97, fig. D, and Pl. 4, fig. 25; Ortmann, 1911*b*, Pl. 89, fig. 18; Coker & Surber, 1911, Pl. 1, fig. 3; Lefevre & Curtis, 1912, p. 146, fig. D; Surber, 1912, Pl. 1, fig. 8. My measurements of the glochidia are: $0.20 \times 0.38$; Lefevre & Curtis give: $0.23 \times 0.41$; and Surber: $0.220 \times 0.380$ mm.

*Breeding season:* The following dates for gravid females are at hand: June 24, 1909 (eggs); August 29, 1908; Aug. 30, 1909; Sept. 6, 1914; Sept. 8, 1908; Sept. 10, 1908; Sept. 15, 1913; Sept. 17, 1908; Sept. 17, 1913; Sept. 23, 1908; Sept. 25, 1908; Sept. 28, 1911; Oct. 3, 1908. Then again in spring: May 21, 1909; May 22, 1914; May 23, 1914; May 24, 1911 (discharging); July 7, 1910 (discharging); July 8, 1910 (discharging); July 11, 1909 (discharging).

The species seems to breed all the year round, and the breeding seasons appear to overlap in June and July. Eggs have been found as early as June 24 (at Kelly) but this might be an exceptional case. At the end of August fully developed glochidia are present. On the other hand discharging females have been found as late as July 11. These extreme dates refer to the Ohio-drainage. In Lake Erie the time for discharging is the same, and I found females in this condition in May as well as in the beginning of July. The beginning of the breeding season has not been observed in the lake.

*Remarks:* This is a species easily recognized by the large, winged shell, with blackish epidermis, and purple nacre. In its external shape it much resembles *Lasmigona complanata* (Barnes), while on the inside of the shell (hinge and nacre) it is very different from it.

*Proptera alata* varies greatly in outline, chiefly on account of the variability of the wing. In old specimens, sometimes also in young ones, the wing is almost absent, and often it appears as if broken off in life.

The form from Lake Erie is distinguishable from the Ohio-form. It is smaller, darker brown (not black), has a lighter nacre, and is on the average slightly more swollen. A greater regularity of the growth rests (as is usual in lake-shells) is

not evident in this case. If it should be considered desirable to distinguish the Lake Erie form taxonomically, we should bear in mind that the type-locality for *U. alatus* is Lake Erie, and that the lake-form should retain this name. The form from the Ohio-drainage should then be known as *P. alata megaptera* (Rafinesque) (1820).

*Localities in Pennsylvania represented in the Carnegie Museum:*

Ohio River, Shippingport, Cook's Ferry, and Industry, Beaver Co.; Dead Man's Island (Q. T. Shafer & A. T. Shafer), Coraopolis (S. N. Rhoads), Neville Island, and Edgeworth (G. H. Clapp), Allegheny Co.

Allegheny River, Natrona, Allegheny Co.; Aladdin, Godfrey, Johnetta, Kelly, and Templeton, Armstrong Co.

Little Beaver Creek, Cannelton, Beaver Co. (Miss Vera White).[160]

Monongahela River, Westmoreland Co., and Charleroi, Washington Co. (G. A. Ehrmann).

Dunkard Creek, Wiley, Greene Co.

Lake Erie, Presque Isle Bay, Erie, Erie Co.

*Other localities represented in the Carnegie Museum:*

*Lake-drainage:*

Lake Erie, Vermilion (C. Goodrich), Cedar Point (C. Brookover), and Sandusky Bay, Cedar Point (O. E. Jennings), Erie Co., Ohio; La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).

Maumee River, Roche de Boeuf Rapids, Lucas Co.; Defiance, Defiance Co., Ohio (C. Goodrich).

*Ohio-drainage:*

Ohio River, Congo, Hancock Co., West Virginia; Toronto, Jefferson Co., Ohio; Wheeling, Ohio Co., West Virginia (W. F. Graham); St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.

Little Kanawha River, Grantsville, Calhoun Co. (W. F. Graham); Burnsville, Braxton Co., West Virginia.

Pocatalico River, Raymond City, Putnam Co., West Virginia.[161]

Levisa Fork Big Sandy River, Prestonsburg, Floyd Co., Kentucky.

Licking River, Farmer, Rowan Co., Kentucky.

*Tennessee-drainage:*

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).

Paint Rock River, Paint Rock, Jackson Co., Alabama (H. H. Smith).

Tennessee River, Brabsons Ferry, Knox Co., Tennessee.

French Broad River, Boyd Creek, Sevier Co., Tennessee.

Nolichucky River, Chunns Shoals, Hamblen Co., Tennessee.

Holston River, McMillan and Mascot, Knox Co.; Hodges, Jefferson Co.; Turley Mill, Noeton, and Holston Station, Grainger Co., Tennessee.[162]

[160] I have seen a dead shell in Little Beaver Creek at Smith's Ferry, Beaver Co.

[161] I have seen dead specimens in Elk River at Shelton and Clay, Clay Co., and at Sutton, Braxton Co., West Virginia.

[162] I have seen a dead specimen in the North Fork of the Holston at Rotherwood, Hawkins Co., Tennessee.

Clinch River, Solway, Knox Co.; Edgemoor and Offutt, Anderson Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Clinchport, Scott Co., Virginia.

Powell River, Combs, Claiborne Co., Tennessee.

*Mississippi and westward:*

Mississippi River, Muscatine, Muscatine Co., Iowa (Hartman collection); Moline, Rock Island Co., Illinois (P. E. Nordgren).

Osage River, Warsaw, Benton Co., Missouri (W. I. Utterback).

Bull Creek, Miami Co., Kansas (C. Goodrich, donor) (Osage-drainage).

Kansas and Wakarusa Rivers, Lawrence, Douglas Co., Kansas (R. L. Moodie).

*Distribution and Ecology in Pennsylvania* (See fig. 26): This species has two ranges in Pennsylvania: one in the Ohio system; the other in Lake Erie. In the latter it is found in Presque Isle Bay, but is comparatively rare.

In the Ohio system, it belongs to the three large rivers, the Ohio, Allegheny and Monongahela, and ascends the Allegheny to Armstrong Co., but is rare there: Marshall's record from Warren County should be disregarded. In the Monongahela, it is known from the neighborhood of Charleroi, but must once have gone farther up, to near the West Virginia state-line, for it is found (although very rarely) in the lower part of Dunkard Creek in Greene Co. There is only one other instance known where it enters a small tributary, this is Little Beaver Creek in Beaver County, and there also it is very rare. None of the other tributaries of the Ohio system contains this species, which is most remarkable especially in the case of the Beaver River, where this species has never been found.

In the Ohio below Pittsburgh *P. alata* is common, sometimes even very abundant, and here it is found in riffles, in fine and often rather coarse gravel. It is a rather active species, crawling around a good deal. It is also found on the shell-banks at Industry and Shippingport, associated with the other bank-forming species, in gravel and strong, steady currents.

In Lake Erie (Presque Isle Bay), it is found in the characteristic sand of the north shore of the bay, in from two to three feet of water, and seems to prefer the open shores (not covered and fringed by rushes).

*General distribution: Type locality,* Lake Erie (Say).

The centre of distribution is in the northern section of the interior basin, in the Mississippi and Ohio Rivers, and their tributaries. In the Ohio its upper boundary has been located in western Pennsylvania. Like *Paraptera fragilis,* it passes northward into the northern drainage systems of the Red River of the North, of Hudson Bay and of the St. Lawrence. In the latter it is found principally in the lower lakes and their tributaries, as far as Ottawa (Bell, 1859; Whiteaves, 1863) and it also goes into Lake Champlain, Lake George, and the Hudosn-

drainage in New York, Waterford, Saratoga Co. (De Kay, 1843) Troy, Rensselaer Co. (Aldrich, 1869). Compare also Marshall (1895).

Westward it extends to eastern Kansas (Scammon, 1906), and is also present in the southern tributaries of the Ohio in West Virginia, Kentucky, Tennessee (Marshall, 1895; Lewis, 1871; Wilson & Clark, 1914; Carnegie Museum) and northern Alabama (Call, 1885; Carnegie Museum). In the Clinch River it reaches Virginia.

Within the range thus indicated, this species seems to be present chiefly in the larger rivers, but sometimes it is found in rather small streams.[163] Judging from the Ohio below Pennsylvania, it is a species of the shell-banks in the deep channels, and is taken in great numbers by the clam-diggers, but rejected as useless. According to Baker (1898*a*) Call (1900) and Scammon (1906) it lives in the larger lakes and rivers on muddy bottoms, but it certainly is not often found in mud in Pennsylvania, where it occurs mostly in gravel.

Toward the south *P. alata* just reaches Kansas and (in the Tennessee) northern Alabama. Beyond these stations, it is represented by allied, but distinct species or forms. The true *P. alata* is positively missing from the Alabama-drainage. Simpson (1914, p. 164) reports a form from this region, which is also represented in the Carnegie Museum from the Coosa River, called var. *poulsoni* (Conrad). This indeed closely resembles *P. alata*, but in my opinion is a variety of *P. purpurea* (Lamarck). I cannot go into details here, but we have in this case probably to deal with an interesting instance of "convergency."

## Genus Toxolasma Rafinesque (1831).

*Carunculina* Ortmann, 1912, p. 337 (subgenus of *Eurynia*); *Carunculina* Simpson, 1914, p. 148 (subgenus of *Lampsilis*); *Toxolasma*, Frierson, 1914, p. 7; *Carunculina* (genus) Ortmann, 1914, p. 68.

Type *Unio lividus* Rafinesque.[164]

Only one species is known from Pennsylvania.

[163] Its absence in the Tuscarawas River in Ohio has been noticed by Sterki (1907). This corresponds to its absence in the Beaver River in Pennsylvania.

[164] This is the Tennessee-Cumberland form of *U. glans* Lea. Particulars have been published elsewhere.

### Toxolasma parvum (Barnes) (1823).

*Lampsilis parva* (Barnes) Simpson, 1914, p. 151.

Plate XVI, fig. 3.

*Records from Pennsylvania:*

Harn, 1891 (western Pennsylvania).[165]
? Rhoads, 1899 (Beaver River, Wampum, Lawrence Co.)[166]
Ortmann, 1909*b*, p. 191.

*Characters of the shell:* Shell small, but rather solid. Outline subelliptical, with the anterior and posterior ends almost uniformly and broadly rounded. Lower margin gently convex or nearly straight, and almost parallel to the upper margin. Beaks more or less inflated, slightly elevated above the hinge-line, located anterior to the middle of the shell. Beak-sculpture distinct, consisting of five or six comparatively strong, subconcentric bars, of which the later ones are subangular behind. Valves more or less convex, often considerably inflated (chiefly in the female), flattened upon the sides. No distinct posterior ridge. Posterior slope flattened and somewhat compressed.

Epidermis thick, dark, greenish, brown, or blackish, without rays. Growth-rests not indicated by concentric bands.

Hinge well-developed. Two pseudocardinals in left, one in right valve, triangularly projecting, with rough edges. Interdentum absent. Laterals straight, rather long, moderately strong. Beak-cavity moderately deep. Dorsal muscle-scars in beak-cavity. Anterior adductor-scars distinct and well impressed, posterior ones less so. Nacre silvery white.[167]

Sexual differences present in the shell, but not very pronounced. As a rule the male shells are less swollen, while the females are much more so (almost subcylindrical). In the male the posterior end of the shell is narrower, sometimes almost pointed, while in the female it is more broadly rounded and very blunt; but there is great variability in this respect, and only in the older shells are these differences unmistakable.

| | | L. | H. | D. |
|---|---|---|---|---|
| *Size:* 1. | Conneautlake, Cat. No. 61.3534 | 32 mm. | 19 mm. | 15 mm. |
| 2. | do. Cat. No. 61.4101 | 30 " | 18 " | 14 " |
| 3. | do. " " do. | 27 " | 17 " | 11 " |
| 4. | do. " " do. | 23 " | 13 " | 9 " |

Nos. 2, 3, and 4 are gravid females, and No. 1 also has the shape of a female.

[165] Unfortunately Harn does not give exact locality, so that this record cannot be controlled.
[166] Very likely incorrect, founded upon confusion with *Eurynia fabalis*.
[167] I have a few southern specimens, which have a faint pinkish blush.

*Soft parts* (See Ortmann, 1912, p. 338). They have been figured by Lea, Obs. VII, 1860, Pl. 29, fig. 102. As to the possible hermaphroditism of this species, see Utterback (1916, p. 165). This question is yet rather obscure. *Glochidia:* Lea (Obs. XIII, 1874, Pl. 21, fig. 3); Surber (1915, fig. 3); Utterback (1916, p. 165). I have seen the glochidia of specimens from Arkansas. They are subovate, higher than long, 0.18 × 0.20 mm. Surber gives: 0.17 × 0.20. In Utterback's figures (0.175 × 0.100) apparently is a misprint.

*Breeding season:* In Pennsylvania I found three gravid females with eggs on June 17, 1909, which would indicate a very early beginning of the season. But on the other hand I have females from Arkansas with fully developed glochidia collected June 26, 1911, and May 19, 1911. A specimen from Indiana, collected Aug. 9, 1912, had eggs. Surber's glochidia came from a specimen collected July 20, 1911. This is rather confusing, and additional data are much to be desired.

*Remarks:* The chief characteristics of this species are the small size, rather regular subelliptic outline, the inflated valves, dark epidermis, and beak-sculpture. In Pennsylvania it apparently has been confounded with *Eurynia fabalis,* which resembles it in its small size, but is more compressed, is more pointed behind, has much heavier hinge teeth, and generally more or less distinct rays.

*Localities represented in the Carnegie Museum:*

Conneaut Outlet, Conneautlake, Crawford Co., Pennsylvania.
Lake Erie, Put-in-Bay, Ottawa Co., Ohio (C. Goodrich).
Crane Creek, and Ten Mile Creek, Ottawa Park, Lucas Co., Ohio (C. Goodrich).
Grand Reservoir, Mercer Co., Ohio (C. Goodrich).[168]
Tuscarawas River, Ohio (Holland collection).
Scioto River and Ohio Canal, Columbus, Franklin Co., Ohio (Smith collection).
Wabash River, Mercer Co., Ohio (C. Goodrich); New Harmony, Posey Co., Indiana (A. A. Hinkley).
Big Creek, Solitude, Posey Co., Indiana (A. A. Hinkley).
Hinkston Creek, Columbia, Boone Co., Missouri (D. K. Greger).
Saline River, Benton, Saline Co., Arkansas (H. E. Wheeler).
Ouachita River, Arkadelphia, Clark Co., and mouth of Cove Creek, Hot Springs Co., Arkansas (H. E. Wheeler).
Big Deceiper Creek, Gum Springs, Clark Co., Arkansas (H. E. Wheeler).
Malvern Creek, Malvern, Hot Springs Co., Arkansas (H. E. Wheeler).
Slough, Tulsa, Tulsa Co., Oklahoma (F. B. Isely).

*Distribution and Ecology* (See fig. 27): *Type locality,* Fox River, Wisconsin (Barnes).

In Pennsylvania this species is known from but one locality, the outlet of Conneaut Lake. Here I found it in small numbers at a point where a small run

[168] This drains originally into the Maumee, but now into the Wabash at high water.

empties into the outlet, the water of the former being backed up and transformed into a quiet pool. It lives here in mud.

This species has been reported from western New York in the Erie Canal in Onondaga Co., and in the Genesee Canal (Marshall, 1895). It is possible that these localities may later be discovered to be connected with the Pennsylvanian

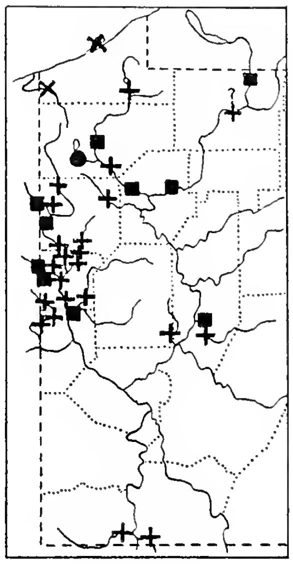

FIG. 27.

● *Toxolasma parvum.*

■ *Eurynia fabalis.*

+ *Eurynia iris.*

× *Eurynia iris novi-eboraci.*

locality, and this in turn with the western localities, when the species is looked for at favorable habitats (canals, sloughs, etc.). In the state of Ohio it is not rare, and is found in both drainages, and also in Lake Erie (Sterki, 1907*a*; Walker, 1913, p. 21). It is known in the lake-drainage in southern Michigan (Walker, 1898), and is found practically all over Indiana (Call, 1896*a*) and Illinois (Baker, 1906). Here it does not enter the lake-drainage, except in the Maumee River (Call). It is known from Fox River, Wisconsin, from southern Minnesota (Call, 1885; Grant, 1886; Holzinger, 1888), from Iowa (Pratt, 1876; Witter, 1878; Call, 1895; Marshall, 1895; Geiser, 1910). Thence it extends southward, and is found in Missouri (Utterback, 1916), in Kansas (Scammon, 1906), Arkansas (Call, 1895; Wheeler, 1918; see also Carnegie Museum), Oklahoma, and as far south as Texas (Singley, 1893). However, in this region a closely allied species, *T. texasense* (Lea) turns up, and this seems to gradually replace it (see Simpson, 1900, p. 564, footnote 2) and possibly the two forms intergrade. According to Vaughan (1893) they run into each other in northwestern Louisiana.

South of the Ohio in Kentucky and Tennessee definite records are scarce. Wilson & Clark (1914) give it from Stones River in Tennessee, a tributary of the Cumberland. Call reports it (1885) from the Tennessee-drainage near Tuscumbia, Alabama, and from Jackson, Hinds Co., Mississippi. But in this region and also in Alabama it is supposed to be replaced by several other species, the standing of which is very doubtful.

According to Baker (1898*a*) and Scammon (1906), this is a species living buried in mud, in sluggish streams, canals, etc. This is supported by my observations in Pennsylvania.

## Genus Eurynia Rafinesque (1820).

Ortmann, 1912, p. 336.[169]

Type *Unio recta* Lamarck.

Four species, and one variety are found in Pennsylvania. They fall into two subgenera.

Key to the Subgenera of Eurynia.

$a_1$. Inner edge of mantle in front of the branchial opening in the female with irregular, larger or smaller papillæ, generally rather distant from each other. Shell small or of medium size, subovate or subelliptical, not very long (hardly over twice as long as high). Glochidia subspatulate, considerably higher than long. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . Subgenus *Micromya*.

$a_2$. Inner edge of mantle in front of branchial opening in the female with a long row of quite regular, uniform, smaller or larger papillæ, which stand rather crowded. Shell of medium or large size, subelliptical, elongated, distinctly over twice as long as high. Glochidia subovate, only slightly higher than long. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . Subgenus *Eurynia*.

## Subgenus Micromya Agassiz (1852).

Ortmann, 1912, p. 337.[170]

Type *Unio fabalis* Lea.

Two species and a variety in Pennsylvania.

Key to the Forms of Micromya.

$a_1$. Shell very small. Hinge-teeth comparatively thick and heavy. Rays faint, broad or fine, often somewhat undulating. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *E.* (*M.*) *fabalis*.

$a_2$. Shell larger, up to middle size. Hinge-teeth thin and delicate. Rays more or less distinct, not undulating, but often interrupted.

$b_1$. Rays straight and continuous, often indistinct. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *E.* (*M.*) *iris*.

$b_2$. Rays interrupted, forming blotches, generally well-developed. . . . . . . . . *E.* (*M.*) *iris novi-eboraci*.

[169] *Eurynia* (as subgenus of *Lampsilis*) Simpson, 1914, p. 60, is only in part identical with *Eurynia* in our sense.

[170] The genus *Micromya* of Simpson (1914, p. 32) contains two species, of which only the first (*fabalis*) belongs here. The other species of *Micromya* in our sense stand under *Lampsilis* Simpson.

Eurynia (Micromya) fabalis (Lea) (1831).

*Micromya fabalis* (Lea) Simpson, 1914, p. 33.

Plate XVI, figs. 4, 5.

*Records from Pennsylvania:*

Harn, 1891 (western Pennsylvania).
Marshall, 1895 (Allegheny River, Warren Co.).
Ortmann, 1909*b*, p. 188.[171]

*Characters of the shell:* Shell small, but comparatively thick. Outline subelliptical to subovate, rather short, generally a little less than twice as long as high. Anterior and posterior ends rounded. Upper and lower margins more or less curved, the lower sometimes nearly straight, or even concave in the middle. Beaks not much elevated above the hinge-line. Beak-sculpture fine and rudimentary, consisting of four or five bars, which are double-looped and interrupted in the middle. The posterior loop is represented by a mere tubercle. Valves more or less convex, flattened upon the sides. No distinct posterior ridge. Posterior slope slightly convex.

Epidermis yellowish, or light or dark green. Generally covered all over with green rays, but the rays may be absent on the anterior section. The rays are not very sharp, and are broader or narrower, but on the posterior section of the shell they are generally rather narrow, and very often more or less undulating. On the posterior slope they are indistinct. Old shells often incline to a uniform dark green, brown, or blackish color, with very indistinct rays. Growth-rests obscure.

Hinge well-developed. Pseudocardinals two in left, one or two in right valves, comparatively heavy, thick, stumpy, and somewhat crenulated. Interdentum absent or narrow. Laterals moderately long, thick and heavy, especially the one in the right valve, which stands upon a heavy basal plate. Beak-cavity shallow. Dorsal muscle-scars in the beak-cavity. Adductor-scars distinct, and rather deeply impressed, especially the one anterior. Nacre silvery white, sometimes faintly salmon or pinkish toward the beak-cavity; more or less iridescent posteriorly.

Sexual differences rather well marked. The male shell is not much swollen, and has a long-ovate outline, with the posterior end narrower and more narrowly rounded than the anterior. The lower margin is generally gently curved. In the female shell, which is generally more inflated, the outline is more subelliptical, and the posterior end more broadly rounded than in the male. This is brought

[171] Rhoad's *Unio parvus* (1899) from Beaver River, Wampum, Lawrence Co., refers probably to this species.

about by a slight swelling and prominence of the lower margin in the postbasal region, and in consequence of this the lower margin is straighter in the middle, or even slightly concave. The undulating character of the rays is generally more pronounced in the female in the region of the postbasal swelling. On the average the female shell also appears a little shorter and higher than the male shell.

| | | | L. | H. | D. |
|---|---|---|---|---|---|
| *Size:* | (Males) | 1. Utica, Cat. No. 61.3377 | 37 mm. | 20 mm. | 12 mm. |
| | | 2. Sharpsville, Cat. No. 61.3378 | 32 " | 18 " | 10 " |
| | | 3. Utica, Cat. No. 61.3377 | 30 " | 16 " | 9 " |
| | | 4. Rosston, Cat. No. 61.2933 | 27 " | 15 " | 9 " |
| | (Females) | 5. Walnut Bend, Cat. No. 61.3376 | 31 " | 18 " | 11 " |
| | | 6. Russell, Cat. No. 61.3375 | 29 " | 19 " | 12 " |
| | | 7. Sharpsville, Cat. No. 61.3378 | 28 " | 17 " | 11 " |
| | | 8. Russell, Cat. No. 61.3375 | 27 " | 17 " | 11 " |

The largest specimen in the Carnegie Museum is a male (without locality) 40 mm. long.

*Soft parts* (See Ortmann, 1912, p. 339). *Glochidia* hitherto unknown, but I have seen them in specimens collected in West Virginia. They are of the usual shape, subspatulate, higher than long, but of rather small size. L. 0.17, H. 0.20 mm.

*Breeding season:* Gravid females were found on May 13, 1911; May 23, 1911; May 23, 1912. In every case glochidia were present. This agrees with the assumption that the species is *bradytictic*. Nothing is known about the beginning of the breeding season.

*Remarks:* This species, and *Toxolasma parvum*, are the smallest in our fauna, and could not be possibly confounded with any others. The differences of these two have been pointed out under *Toxolasma parvum*. *Eurynia fabalis* can be easily recognized by the combination of a small shell with comparatively heavy hinge teeth, and in this it also differs from the young of other species, for instance *E. iris*. It also has a certain resemblance to young *Elliptio dilatatus*, but the latter is generally longer and thinner, has less heavy teeth, more or less deeply colored nacre, and not the peculiar rays seen in *E. fabalis*.

I have only one specimen from Lake Erie (in Michigan): it is very small (13 mm. long), and has a rather bright green color. I can not tell whether there are any striking differences from the normal type.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Mahoning River, Mahoningtown, Coverts and Edinburg, Lawrence Co.
Shenango River, Sharpsville, Mercer Co.

Pymatuning Creek, Pymatuning Township, Mercer Co.
Allegheny River, Walnut Bend, Venango Co.
Crooked Creek, Rosston, Armstrong Co.
French Creek, Utica, Venango Co.; Meadville, Crawford Co.
Connewango River, Russell, Warren Co.

*Other localities represented in the Carnegie Museum:*

*Lake-drainage:*

Lake Erie, La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).
Sandusky River, Upper Sandusky, Wyandot Co., Ohio (C. Goodrich).
Swan Creek, Toledo, Lucas Co., Ohio (C. Goodrich).
Maumee River, Fort Wayne, Allen Co., Indiana (C. Goodrich).

*Ohio-drainage:*

Tuscarawas River, Ohio (Holland collection).
Ohio Canal, Columbus, Franklin Co., Ohio (Smith collection).
West Fork River, Lynch Mines, Harrison Co.; Lightburn and Weston, Lewis Co., West Virginia.
Elk River, Clay, Clay Co., West Virginia.

*Tennessee-drainage:*

Holston River, Mascot, Knox Co.; Noeton, Grainger Co.; Church Hill, Hawkins Co., Tennessee.
South Fork Holston River, Pactolus, Sullivan Co., Tennessee.
North Fork Holston River, Rotherwood, Hawkins Co., Tennessee; Hilton, Scott Co., Virginia.
Clinch River, Clinch River Station, Claiborne Co., Tennessee; Speers Ferry, Scott Co., Virginia; St. Paul, Wise Co., Virginia; Cleveland, Russell Co., Virginia.
Powell River, Combs, Claiborne Co., Tennessee.

*Distribution and Ecology in Pennsylvania* (See fig. 27): This is a rather rare and local shell in western Pennsylvania, and has been found chiefly in small streams in small numbers. It has never turned up in the Monongahela-drainage in our state, but it is in the headwaters in West Virginia (West Fork River). Probably the species is more abundant than the records show, but is often overlooked, or not hunted for at the proper places. I found it in and near riffles, generally in patches of *Dianthera americana*, or among other water weeds (*Heteranthera*, in the upper Allegheny, or *Potamogeton*, *Vallisneria*, etc.). According to observations made in West Virginia it distinctly prefers these plants, in riffles, and is deeply buried in the sand and gravel bound together by their roots and rhizomes. By pulling up the plants it sometimes was brought to light in goodly numbers.

*General distribution: Type locality*, Ohio (Lea). This species belongs to the Ohio-drainage, and from this it has crossed over into the lake-drainage in southeastern Michigan and northern Ohio (Conrad, 1836; Marshall, 1895; Sterki, 1907*a*; Walker, 1898). It is also found in the western end of Lake Erie (Walker, 1913, p. 21). It has been reported from western New York, but the only known

locality is Chautauqua Lake (Marshall), and this undoubtedly has been reached from the upper Allegheny. In Indiana (Call, 1896*a*, 1900) it is in the Ohio and Wabash basins, and in some of the lakes in the northern part of this drainage, Tippecanoe (Wilson & Clark, 1912*a*) Winona and Pike (Norris, 1902; Headlee, 1906), and here enters the Lake Michigan-drainage, St. Joseph basin (Call, 1900). From Illinois it has been reported from the Wabash River (Baker, 1906).

It is in the upper Monongahela and Elk River in West Virginia. Records from Kentucky are lacking and Wilson & Clark (1914) do not report it from the Cumberland, but it is known from the Tennessee-drainage in Tennessee, Duck River, Columbia, Maury Co. (Marshall, 1895), and is rather abundant in the headwaters in East Tennessee, going up here to Virginia.

It is unknown to the south and the west of this range.

Little is known as to its ecology. Headlee (1906) gives some particulars with regard to its occurrence in lakes.

### EURYNIA (MICROMYA) IRIS (Lea) (1830).

*Lampsilis iris* (LEA) SIMPSON, 1914, p. 113.

Plate XVI, figs. 6, 7.

*Records from Pennsylvania:*

Harn, 1891 (western Pennsylvania).
Simpson, 1900, p. 553 (Beaver River, Pennsylvania) (as *L. fatuus*).[172]
Ortmann, 1909*b*, p. 191.

*Characters of the shell:* Shell of medium size, moderately thick anteriorly, rather thin posteriorly. Outline subelliptical or subovate, moderately elongated, about twice as long as high. Anterior and posterior ends rounded. Upper and lower margins gently convex, the lower sometimes nearly straight. Beaks not much elevated. Beak-sculpture consisting of four to six fine, but distinct, bars, the first subconcentric, the others distinctly double-looped. Sometimes the later bars become irregular. Valves convex, flattened upon the sides. No distinct posterior ridge.

Epidermis yellowish to light green, with dark green rays. The rays are more or less distinct, sharply or poorly defined, rather narrow, straight, and mostly not interrupted. Often there are concentric bands of color, indicating, in part, the growth-rests.

Hinge well-developed. Pseudocardinals two in left, one in right valve, triangular, a little compressed and crenulated, not heavy. Interdentum absent.

[172] A specimen so labeled by Simpson is in the Carnegie Museum.

Laterals long, thin and narrow. Beak-cavity shallow. Dorsal muscle-scars in beak-cavity. Anterior adductor-scars distinct and well impressed, those posterior faint and indistinct. Nacre silvery white, highly iridescent posteriorly.

Sexual differences present in the shell, but not always very striking. The male shell has the posterior end more or less attenuated, narrower than the anterior end, and the lower margin has a rather regular curve. In the female shell the lower margin is a little expanded in the postbasal region, so that its middle part is nearly straight, and its posterior part curves up more strongly. In consequence of this, the posterior end of the shell is more broadly rounded, and more nearly resembles the anterior end. There are cases, in which the female character is very slightly developed, and others, where males do not show very well the posterior tapering of the shell. As a rule, however, the sexes are rather easily distinguishable. Female shells seem to be smaller on the average than male shells.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Edinburg, Cat. No. 61.3531 (probably ♂) | 92 mm. | 47 mm. | 32 mm.[173] |
| 2. New Galilee, Cat. No. 61.1797 (sex ?) | 71 " | 34 " | 22 " |
| 3. New Galilee, Cat. No. 61.3265 (♂) | 68 " | 36 " | 23 " |
| 4. Pulaski, Cat. No. 61.4830 (♂) | 55 " | 27 " | 18 " |
| 5. New Galilee, Cat. No. 61.3265 (♀) | 49 " | 26 " | 17 " |
| 6. Waterford, Cat. No. 61.4096 (♀ gravid) | 43 " | 24 " | 13 " |

*Soft parts* (See Ortmann, 1912, p. 341, fig. 23). *Glochidia* (See Ortmann, 1912, p. 342). They are identical with those of the var. *novi-eboraci* according to Surber (1912, Pl. 3, fig. 46). Surber gives the measurements: $0.240 \times 0.300$, while I gave: $0.22 \times 0.28$ mm.

*Breeding season:* The following records are at hand: Sept. 14, 1909; Sept. 18, 1917; and May 11, 1907; May 13, 1910; May 13, 1911; May 23, 1911; May 24, 1911; July 30, 1914. All my specimens had glochidia. Surber (1912, p. 7) found glochidia in September, and Wilson & Clark (1912) report this species as gravid (in Kankakee River) on July 28, and Aug. 3. All this speaks for a bradytictic form.

*Remarks:* This is a shell well characterized by size, shape, and color. It can not be easily confounded with any other Pennsylvanian species. However, young specimens somewhat resemble *E. fabalis*, but are distinguishable at a glance by the relatively thinner shell, and weaker hinge teeth. The extreme brilliancy of the nacre in the posterior section of the shell is also characteristic of this species. The latter character distinguishes *E. iris* also from young *Lampsilis luteola,* which resembles it to some extent. In addition *L. luteola* has more distinctly defined

[173] A giant, and apparently an exceptional case.

rays (if rays occur) and no concentric bands indicating growth-rests, by which fact the young of *L. luteola* may be recognized as being juvenile. Old specimens of *L. luteola* are much larger.

There is a great deal of variability in the character of the rays of *E. iris,* and below I shall discuss a northern race (*novi-eboraci*), the chief difference of which consists in the color-pattern. Otherwise our specimens of *E. iris* are very uniform in their characters.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Little Beaver Creek, Cannelton (Miss Vera White) and New Galilee, Beaver Co.; Enon Valley, Lawrence Co.
Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).[174]
Slipperyrock Creek, Wurtemberg, Lawrence Co.
Mahoning River, Mahoningtown and Edinburg, Lawrence Co.
Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Jamestown, Mercer Co.
Neshannock Creek, Eastbrook and Volant, Lawrence Co.; Leesburg, Mercer Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Buffalo Creek, Harbison, Butler Co.
Crooked Creek, Rosston, Armstrong Co.
Sandy Creek, Sandy Lake, Mercer Co.
French Creek, Cochranton, Crawford Co.
Leboeuf Creek, Waterford, Erie Co.
Dunkard Creek, Wiley, Greene Co.
Cheat River, Cheat Haven, Fayette Co.

*Other localities represented in the Carnegie Museum:*

West Fork River, Lynch Mines, Harrison Co.; Lightburn and Weston, Lewis Co., West Virginia.
Little Kanawha River, Burnsville, Braxton Co., West Virginia.
North Fork Hughes River, Cornwallis, Ritchie Co., West Virginia.
Elk River, Shelton, Clay Co.; and Sutton, Braxton Co., West Virginia.
Little Coal River, Boone Co., West Virginia (Hartman collection).
James River, Galena, Stone Co., Missouri (A. A. Hinkley).

*Distribution and Ecology in Pennsylvania* (See fig. 27): Like the preceding species (*E. fabalis*) *E. iris* is restricted to the Beaver-drainage and certain tributaries of the Allegheny and Monongahela, and has been found in addition in Little Beaver Creek. It is also present in the upper Monongahela in West Virginia. It has never been found in the large rivers. It seems to prefer localities like those frequented by *E. fabalis* (*Dianthera*-patches), and is altogether a rare shell.

*General distribution: Type locality,* Ohio (Lea).

The exact range of this species is hard to determine, since it has often been confounded with its var. *novi-eboraci,* and because there are kindred forms in the

[174] One specimen determined by Simpson as *L. fatuus* (Lea).

Tennessee-drainage, which are not well distinguished from it, *e. g.*, *E. nebulosa* (Conrad). Whether it occurs in the state of New York is doubtful, but it might be found in the upper Allegheny-drainage. As the material in the Carnegie Museum shows, it exists in the tributaries of the Ohio in West Virginia. In Ohio it is certainly present, but Sterki (1907*a*) does not separate the two forms. The form from Lake Erie undoubtedly belongs to *novi-eboraci*. It ranges practically all over Indiana (Call, 1896*a* and 1900), and here crosses over into the lake-drainage according to Call. Nevertheless it is quite probable that in northern Indiana its place is taken by the variety; at all events, specimens from Winona Lake in the Carnegie Museum belong to the latter. In Illinois it is reported from the northern half of the state (Baker, 1906), but the common form of the Chicago area is, according to Baker's description (1898) without doubt the var. *novi-eboraci*. Still in this region it may pass into the typical form.

From the foregoing it appears that the typical *E. iris* belongs to the Ohio-drainage in western Pennsylvania, West Virginia, Ohio, Indiana, and possibly Illinois. It may cross over into the lake-drainage, but it seems to be generally represented there by the var. *novi-eboraci*. Farther to the south it seems to be absent. It has indeed been recorded from the Tennessee-drainage, and closely allied forms certainly occur there, but these require further study. A few other records, such as Wisconsin (Simpson), Louisiana and Texas (Baker, 1898) are extremely doubtful.

Strangely enough, it turns up again in the Ozark region in southern Missouri. Utterback (1916) reports it from the basins of White and Black Rivers, and specimens in the Carnegie Museum (James River) are absolutely indistinguishable from Pennsylvanian specimens.

### EURYNIA (MICROMYA) IRIS NOVI-EBORACI (Lea) (1838).

Simpson, 1914, p. 116, makes this a synonym of *Lampsilis iris* (Lea).

Plate XVI, figs. 8, 9.

*Records from Pennsylvania wanting hitherto.*

*Characters of variety:* This form differs from the typical *E. iris* by the color-pattern. The rays are not fine and more or less continuous, but rather broad, distinct, and more or less interrupted and dissolved into dark, almost black, squarish spots. These spots are generally arranged in concentric bands, so that the color-pattern becomes very attractive.

| | | L. | H. | D. |
|---|---|---|---|---|
| *Size:* | 1. West Springfield, Cat. No. 61.4091 (♂) | 65 mm. | 35 mm. | 23 mm. |
| | 2. do. " " do. (♀) | 51 " | 29 " | 18 " |
| | 3. do. " " do. (♂) | 48 " | 28 " | 17 " |
| | 4. do. " " do. (♀ gravid) | 44 " | 24 " | 13 " |
| | 5. Erie, Cat. No. 61.4832 (♂) | 56 " | 32 " | 21 " |
| | 6. do. Cat. No. 61.4831 (♀) | 56 " | 29 " | 20 " |
| | 7. do. Cat. No. 61.4833 (♂) | 54 " | 28 " | 17 " |
| | 8. do. Cat. No. 61.4093 (♀) | 45 " | 25 " | 16 " |

*Soft parts* identical with those of typical *E. iris* (See Ortmann, 1912, p. 341). *Glochidia* (See Lea, Obs. VI, 1858, Pl. 5, fig. 14; Ortmann, 1911*b*, Pl. 89, fig. 20 as of *E. iris*).

*Breeding season:* May 23, 1909, is the only date, at which I found gravid females. They all had glochidia.

*Remarks:* The color-pattern is the chief diagnostic character of this form. In addition the ground-color of the epidermis is generally lighter than in the typical *E. iris*, but this is not constant. The lake-form differs from that of Conneaut Creek by often (but not always) having the epidermis chestnut-brown especially toward the beaks.

Intergrades seem to be present. Baker (1898*a*) mentioned that the color varies in the Chicago area, and I have transitional specimens from Winona Lake. Even in Lea's types the typical color-pattern is not very well developed.

It should be mentioned, that in shells from the Cumberland and Tennessee drainages belonging to this type, the broken and spotted rays turn up frequently. This will be discussed elsewhere. The geographical relations of these forms which are generally referred to *E. nebulosa* Conrad, are still obscure.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Lake Erie, Presque Isle Bay, Erie, Erie Co.
Conneaut Creek, West Springfield, Erie Co.

*Other localities represented in the Carnegie Museum.*

Mohawk River, New York (Smith collection).
Genesee River, Rochester, Monroe Co., New York (R. H. Santens).
Black Creek, Chili, Monroe Co., New York (R. H. Santens).
Lake Erie, Port Rowan, Norfolk Co., Ontario, Canada (C. Goodrich).
Grand River, Cayuga, Haldimand Co., Ontario, Canada (C. Goodrich).
Sandusky River, Upper Sandusky, Wyandot Co., Ohio (C. Goodrich).
Swan Creek, Toledo, Lucas Co., Ohio (C. Goodrich).
Raisin River, Grape P. O., Monroe Co.; Adrian and Tecumseh, Lenawee Co., Michigan (C. Goodrich).
Winona Lake, Kosciusko Co., Indiana (E. B. Williamson).
Sheyenne River, Argusville, Cass Co., North Dakota (S. M. Edwards).

*Distribution and Ecology* (See fig. 27): *Type locality,* Oak Orchard Creek, Orleans Co., New York (Lea).

This form apparently is a northern race of *E. iris,* and is found along the northern edge of the range of the latter in the lake-drainage. Most of the localities known are in the St. Lawrence-drainage in New York (Marshall, 1895, but quoted generally as *iris*). It is known from the Erie Canal, in Onondaga Co., and from Oneida Co., and by this route it may have crossed over into the Mohawk River (Carnegie Museum).

Our records show that it is in Lake Erie and some of its tributaries in Canada, Pennsylvania, Ohio, and Michigan, and very likely the records from this region given by Sterki (1907*a*) and Walker (1913) are to be referred to this variety. In Michigan it is generally distributed, and since Walker (1898) calls it *novi-eboraci* there is no doubt about it.

Farther west its presence is doubtful. It occurs in Winona Lake (Wabash-drainage!), and Baker's figures make it probable that it is found also in the Chicago area, but particulars are lacking.

From Illinois the range certainly extends farther northwestward, as is shown by our specimens from the drainage of the Red River of the North in North Dakota. This locality is altogether new, for even the typical form has been only doubtfully reported from Wisconsin, without exact locality, and has never been found beyond this state.

I found this variety only once in a creek (Conneaut Creek), and here it was abundant in riffles in fine gravel and sand. In Lake Erie it lives in from one to two feet of water on sandy bottom, and often among a scanty growth of rushes (*Juncus americanus*).

### Subgenus Eurynia Ortmann (1912).

Ortmann, 1912, p. 338.[175]

Type *Unio recta* Lamarck.

Two species exist in Pennsylvania.

#### Key to the Species of the Subgenus Eurynia.

$a_1$. Shell of medium size, rather thin, more or less compressed, with a rather distinct, but rounded posterior ridge. Color of epidermis olive-green to olive-brown. . . . . . . . . . . . . . . . . . . . . . . . . . . *E.* (*E.*) *nasuta.*

$a_2$. Shell large, thick, rather swollen, with the posterior ridge obliterated. Color of epidermis dark green to black, rarely brownish. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *E.* (*E.*) *recta.*

[175] Simpson's (1914, p. 60) conception of the "subgenus" *Eurynia* differs entirely from ours.

EURYNIA (EURYNIA) NASUTA (Say) (1817).[176]

*Lampsilis nasuta* (SAY) SIMPSON, 1914, p. 97.

Plate XVI, figs. 10, 11.

*Records from Pennsylvania:*

Say, 1817 (Delaware and Schuylkill Rivers).
Gabb, 1861 (Schuylkill River and League Island, Philadelphia; "Little Perkiomen Creek").[177]
Hartman & Michener, 1874 (Schuylkill River, Chester Co.).
Marshall, 1895 (Philadelphia).
Schick, 1895 (Delaware and Schuylkill Rivers, Philadelphia).
Ortmann, 1909*b*, p. 202, 205.

*Characters of the shell:* Shell of medium size and medium thickness. Outline subelliptical or sublanceolate, elongated, distinctly over twice as long as high. Anterior margin rounded. Lower margin more or less curved. Upper margin straight or gently curved, forming (at least when young) a distinct angle with the posterior margin, which slopes down obliquely, joining the lower margin in a distinct, but rounded, posterior angle or point. Thus the shell is distinctly attenuated and pointed behind, although the point itself is narrowly rounded. Beaks low, hardly elevated above the hinge-line. Beak-sculpture (Marshall, 1890, fig. 5) consisting of five to seven fine bars, the first one or two subconcentric, the following double-looped, with a distinct re-entering angle or sinus back of the middle. Anterior loop broadly rounded, posterior loop narrow, somewhat angular upon the posterior ridge, and indistinct upon the posterior slope. Valves moderately convex, flattened upon the sides. A posterior ridge is present; it is most distinct near the beaks, and angular, farther downwards it becomes broader, is more rounded and indistinct. Posterior slope slightly concave near the beaks, becoming flatter or even somewhat convex toward the posterior end of the shell. In young shells it is compressed and elevated toward the posterior angle of the upper margin.

Epidermis dark olive-green or brown, with or without rays. The latter are poorly developed, dark green, straight, narrow or somewhat wider, and generally visible only (if at all) in the posterior section of the shell, just in front of the posterior ridge, and upon the posterior slope. In younger specimens the rays may extend over the whole surface. In other cases, they are entirely absent. Sometimes there are concentric light and dark bands, the latter marking the growth-rests.

[176] Not 1816.

[177] Perkiomen Creek is a tributary of the Schuylkill in Montgomery County. There is no "Little Perkiomen Creek" to my knowledge.

Hinge well-developed. Pseudocardinals one or two in left, one or two in right valve, not very large and not heavy, compressed, subtriangular, somewhat crenulated. Laterals long and thin. No interdentum. Beak-cavity shallow. Dorsal muscle-scars in beak-cavity. Adductor-scars distinct, and moderately impressed anteriorly, less distinct posteriorly. Nacre silvery white, often cream-color or salmon toward the beak-cavity, highly iridescent posteriorly.

Sexual differences of the shell well marked. In the male the shell tapers uniformly behind into the posterior point, and the lower margin has a rather uniform curve. In the female the lower margin is distinctly produced in the postbasal portion, there forming a broad, rounded projection, behind which the lower margin slopes up more suddenly, and is at this point straight or even slightly concave.[178]

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Yardley, Cat. No. 61.3525 (largest ♂) | 77 mm. | 35 mm. | 19 mm. |
| 2. Erie, Cat. No. 61.4088 (♂) | 102 " | 44 " | 30 " |
| 3. do. Cat. No. 61.4837 (♀) | 93 " | 45 " | 27 " |
| 4. do. Cat. No. 61.4083 (♂) | 89 " | 42 " | 24 " |
| 5. do. Cat. No. 61.4088 (♀) | 71 " | 33 " | 17 " |
| 6. do. " " do. (♀) | 58 " | 28 " | 15 " |

*Soft parts* (See Ortmann, 1912, p. 343). *Glochidia* (See Lea, Obs. XIII, 1874, Pl. 21, fig. 2; Ortmann, 1912, Pl. 20, fig. 8).

*Breeding season:* Conner (1907) mentions this species as breeding all the year round. From the eastern part of the state I have only two records for gravid females: Sept. 15, 1905 and May 10, 1909, in both cases with glochidia. From Lake Erie I have the following records: end of August, 1909 (eggs), and May 21, 1909; May 22, 1909; May 24, 1909; June 2, 1908; June 3, 1908; July 7, 1910. The dates in early summer furnished glochidia, and on the two last ones, discharging females were found. On and after July 8 numerous females were collected, but none were gravid, so that in Lake Erie, as I have shown (1912, p. 343), a distinct interim exists in July and at the beginning of August.

*Remarks:* This is a species quite easily recognized by its lance-head outline, dull olive-green color, with only indistinct rays, and light-colored nacre. However, it resembles, principally in the male sex certain other species, for instance *Elliptio cupreus* (Rafinesque) and *E. fisherianus* (Lea), and indeed, specimens of the latter have been confounded by Conrad with it. *E. cupreus* and *E. fisherianus* generally have a differently colored nacre (coppery or purple), and differ in the

[178] In old males, there is sometimes a short concavity of the lower margin immediately in front of the posterior end. This is due to a downward deflection of the posterior end, such as is often observed in old specimens of other species.

hinge-teeth, which are more stumpy. The females of these two are entirely different from those of *E. nasuta*, and have never the peculiar expansion of the lower margin.

There is not much variability in *E. nasuta*. The specimens may be a little longer or shorter in outline, and the color of the epidermis may be more greenish or more brownish. In this connection it should be mentioned that specimens from Lake Erie frequently differ from eastern specimens by their rusty brown

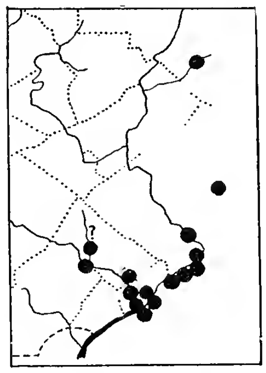


FIG. 28.

● *Eurynia nasuta* (eastern range).

color, especially towards the beaks. This is the effect of the lake environment, which is observed in other species from the lake. But this color is not always present. As usual, specimens from Lake Erie often have very regular growth-rests. In all other characters, the lake-form is absolutely like that of eastern Pennsylvania.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Lake Erie, Miles Grove, and Presque Isle Bay, also beach-pools of Presque Isle, Erie, Erie Co.
Delaware River, Penns Manor and Yardley, Bucks Co.
Schuylkill Canal, Manayunk, Philadelphia Co.

*Other localities represented in the Carnegie Museum:*

Douglas Lake, Cheboygan Co., Michigan (H. B. Baker).
Otter Creek, Monroe Co., Michigan (C. Goodrich).
Ottawa River, Toledo, Lucas Co., Ohio (C. Goodrich).
Lake Erie, La Plaisance Bay, Monroe Co., Michigan (C. Goodrich); Sandusky Bay, Cedar Point, Erie Co., Ohio (O. E. Jennings; C. Brookover); Port Rowan, Norfolk Co., Ontario, Canada (C. Goodrich); Crystal Beach, Welland Co., Ontario, Canada (F. Behrle).
Delaware-Raritan Canal, Princeton, Mercer Co., New Jersey.
Delaware River, Fish House, Camden Co., New Jersey.

*Localities represented in the Philadelphia Academy:*

Delaware River, Kaighn's Point, Camden, Camden Co., New Jersey (John Ford); Delanco (H. A. Pilsbry), Burlington Island (H. W. Fowler), and Florence (H. W. Fowler), Burlington Co., New Jersey.

Swartswood Lake, Sussex Co., New Jersey (H. A. Pilsbry & S. N. Rhoads), drains to Delaware River.

Cohansey Creek, Bridgeton, Cumberland Co., New Jersey (S. N. Rhoads) coastal plain of southern New Jersey.

Potomac River, Washington, D. C. (John Ford); Alexandria, Fairfax Co., Virginia (G. W. Tryon, Jr.).

*Distribution and Ecology in Pennsylvania* (See figs. 28 & 29): In Pennsylvania this species has two ranges: one in the extreme eastern end of the state, and the other in the northwest, in Lake Erie. Its metropolis in the east is found in the tidewaters of the Delaware River; farther up (above Trenton, New Jersey) it is

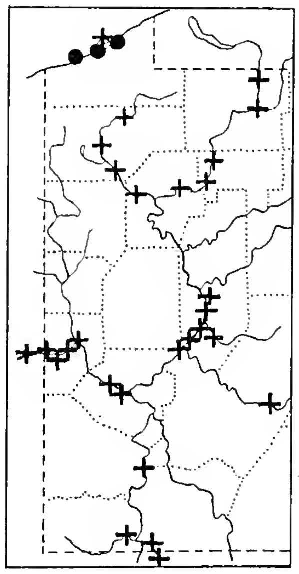

FIG. 29.

● *Eurynia nasuta* (western range).
+ *Eurynia recta.*

rare. It also has been reported from the Schuylkill, probably its lower part, as far up as Chester Co. The record from Perkiomen Creek in Montgomery Co. is doubtful (See above). In addition I found a single individual in the Schuylkill Canal. It has never been found in any of the smaller tributaries, and no records are at hand from anywhere in the Susquehanna or Potomac drainages in Pennsylvania.

I found it in large numbers in the tidewater of the Delaware opposite Philadelphia at Fish House. Here it inhabits the shores of the Delaware, which resembles rather a lake than a river. The bottom at this point is fine sand, and the

water is subject to the tides. At Penn's Manor I found it in the deep water of a protected cove, on a bottom consisting of mud and vegetable debris. The single specimen from the Schuylkill Canal was in deep black muck, the only one found at Yardley lived in gravel in an eddy in a riffle.

In Lake Erie it is a very common species in Presque Isle Bay, where it is present in all parts on sandy, gravelly, and muddy bottom, in from one to fifteen feet of water, and it is also abundant in certain beach-pools of Presque Isle, on sandy and sandy-muddy bottom.

Sandy bottom of great, quiet bodies of water (tidewaters, lakes and probably also canals) seem to furnish the conditions most favorable to this species.

*General distribution: Type locality,* Schuylkill and Delaware Rivers, Philadelphia (Say).

The distribution of this species is unique: only *Elliptio violaceus* can be compared with it, but even this is by no means identical (See under *E. violaceus*, p. 110, and Walker, 1913). It is found on the Atlantic coastal plain, but does not go far up into the rivers, at least in the southern part of its range. Although Simpson (1900) reports it as far South as North Carolina, I have been able to find as its most southern record only that of Conrad (1836) from James River, Virginia (the figured specimen is from this place). Conrad also gives the Potomac river at Washington, and this is confirmed by other writers (Dewey, 1856; Marshall, 1895) and by specimens in the Philadelphia Academy. It is not known from anywhere in the headwaters of the Atlantic streams in Virginia and Maryland, and I myself never found it in the upper James, the upper Rappahannock, and the Potomac, on the Piedmont Plateau and West of the Blue Ridge. It has been reported from the lowlands in Delaware (Rhoads, 1904). In Pennsylvania its distribution is restricted chiefly to the lowlands, and it is absent in the upper Susquehanna. In New Jersey it is known from the Delaware River and from the coastal plain (Philadelphia Academy). I found it in the Delaware-Raritan Canal, and in addition there is a locality (given above) in Sussex Co., northern New Jersey, belonging to the upper Delaware-drainage, which is highly interesting. It is found in New York in the Hudson River as far up as Troy and Albany (Aldrich, 1869; Marshall, 1895[179]), and a number of localities are known from Connecticut, Rhode Island, and Massachusetts (Linsley, 1845; Perkins, 1869; Carpenter, 1890; Earle, 1835; Gould-Binney, 1870; Marshall, 1895; Johnson, 1915). It goes northward to Keene, Cheshire Co., New Hampshire (Walker & Coolidge, 1908).

From the Hudson-drainage in New York, this species ranges westward through the Mohawk basin and the Erie canal, and enters the St. Lawrence-drainage.

[179] Marshall also gives Delaware River, but no exact locality.

Here it is found in the tributaries of Lake Ontario in New York, and in Hamilton Bay of Lake Ontario in Canada (DeKay, 1843; Marshall, 1895), and reaches the Niagara River and Lake Erie (Marshall). In Lake Erie it extends farther westwards, along the Canadian (Carnegie Museum) Pennsylvanian and Ohio shores (Sterki, 1907*a*; Walker, 1913). In Ohio it is found also in tributaries of the lake in Portage Co. (Dean, 1890, Sterki) and Cuyahoga River (Dean, 1890), and in Ottawa River, Lucas Co. (Carnegie Museum).[180] Further it is found in Michigan over the whole state (Walker, 1898). Call (1896*a*) reports it also from the St. Joseph basin in Indiana, but in 1900 (p. 458) he says that no authentic specimens are known from this state. Farther to the south and west it seems to be replaced by the closely allied *E. subrostrata* (Say).

The western and the eastern ranges seem to be connected from Lake Erie to the Hudson River by the Erie canal, and it is very likely that this species migrated along this route.[181] The direction of the migration probably was from west to east, considering the fact that the only closely allied species, *Eurynia subrostrata*, is a species of the interior basin. Being a species partial to quiet water, it is only natural that it followed the route of the Erie canal. In this case, however, this migration must have been quite recent, and it must be a very late arrival on the coastal plain, where it has spread in recent times, as far South as Virginia, remaining restricted chiefly in the southern part of its range to the Coastal plain. This has been discussed previously in another paper (Ortmann, 1913*a*, p. 378 *et seq.*).

### Eurynia (Eurynia) recta (Lamarck) (1819).

*Lampsilis recta* (Lamarck) Simpson, 1914, p. 95.

Plate XVI, figs. 12, 13.

*Records from Pennsylvania:*

Harn, 1891 (western Pennsylvania).
Clapp, 1895 (Allegheny Co.)
Marshall, 1895 (Allegheny River, Warren Co.)
Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co.)
Ortmann, 1909*b*, pp. 190 and 202.

*Characters of the shell:* Shell large, solid and heavy. Outline subelliptical to sublanceolate, elongated, distinctly over twice (up to two and a half times) as long as high. Anterior margin rounded; lower margin more or less convex. Upper margin nearly straight, passing gradually into the descending posterior

[180] Sterki says: "probably also in the Ohio-drainage, at least along the divide."

[181] This route is more southern than that of *Elliptio violaceus*, where the connection does not go through Lake Erie but is more northern.

margin, which joins the lower margin in a distinct, but rounded, angle, so that the shell is more or less narrowed and pointed at the posterior end. Beaks low, only little elevated above the hinge-line. Beak-sculpture faint and obsolete, consisting of three to five indistinct bars, which are double-looped, with a sinus in the middle; the posterior loop is open, *i.e.*, the bars disappear upon the posterior slope. Valves moderately convex, flattened upon the sides. Posterior ridge practically absent, only toward the beaks is it faintly indicated. Posterior slope gently convex, flat towards the beaks.

Epidermis glossy, dark green to brown or blackish, with indistinct rays or without rays. Young shells are lighter green, with dark green rays of various width, but in the posterior section of the shell the rays are generally rather wide. In old shells, the rays become obscure, and the epidermis is often uniformly dark brown or black. Sometimes concentric bands of dark color, marking growth-rests, are present, but generally the growth-rests are not marked by color.

Hinge well-developed. Pseudocardinals two in left, one or two in right valve, stumpy or slightly compressed, crenulated. No interdentum. Laterals long, strong, rather straight. Beak-cavity shallow. Dorsal muscle-scars in beak-cavity. Adductor-scars distinct, those anterior well impressed, those posterior less so. Nacre white, iridescent posteriorly. Often there is more or less pink or light purple in the beak-cavity and upon the hinge teeth; sometimes all of the nacre is purple, but such specimens have not been found in Pennsylvania.

Sexual differences of shell well marked. In the male, the shell tapers posteriorly rather uniformly to a point, and the posterior part is distinctly narrower than the anterior. In the female, the lower margin is distinctly enlarged in the postbasal part. In front of this widening, the lower margin is straight or slightly concave, behind it slopes up rather suddenly to the posterior point, which, in consequence of this, is more elevated above the base line than in the male. The posterior section of the female shell is not distinctly narrowed, and sometimes even slightly higher than the anterior. However, in some females, the characteristic shape is not very well developed.

| | | | L. | H. | D. |
|---|---|---|---|---|---|
| *Size:* | (Males) | 1. Aladdin, Cat. No. 61.3522 | 177 mm. | 70 mm. | 49 mm. |
| | | 2. Neville Island, Cat. No. 61.706 | 175 " | 70 " | 51 " |
| | | 3. Industry, Cat. No. 61.4077 | 100 " | 41 " | 27 " |
| | | 4. Mosgrove, Cat. No. 61.4075 | 71 " | 31 " | 16 " |
| | (Females) | 5. Cooks Ferry, Cat. No. 61.3519 | 156 " | 67 " | 52 " |
| | | 6. Industry, Cat. No. 61.4077 | 140 " | 60 " | 38 " |
| | | 7. Industry, Cat. No. 61.3518 | 111 " | 47 " | 31 " |
| | | 8. Meadville, Cat. No. 61.3512 | 89 " | 40 " | 23 " |
| | (*Lake Erie-form*) | 9. Erie, Cat. No. 61.4070 (♂) | 118 " | 47 " | 33 " |
| | | 10. do. " " do. (♀) | 112 " | 52 " | 31 " |

The species is said to grow even larger than the largest specimens listed above, but Pennsylvanian specimens compare favorably with specimens from other localities.

*Soft parts* (See Lefevre & Curtis, 1910, Pl. 1, fig. 5; 1912, Pl. 7, fig. 6; Ortmann, 1912, p. 344, fig. 24). *Glochidia:* Lea, Obs. VI, 1858, Pl. 5, fig. 11; Lefevre & Curtis, 1910, p. 97, fig. L; Ortmann, 1911*b*, Pl. 89, fig. 21; Lefevre & Curtis, 1912, p. 146, fig. L; Surber, 1912, Pl. 2, fig. 17. My measurements are: 0.22 × 0.28; those of Lefevre & Curtis: 0.20 × 0.24; those of Surber: 0.220 × 0.280 mm.

*Breeding season:* I have the following records of gravid females: Aug. 13, 1907; Aug. 29, 1908; Aug. 30, 1909; Sept. 1, 1908; Sept. 3, 1908; Sept. 5, 1908; Sept. 6, 1908; Sept. 7, 1914; Sept. 8, 1908; Sept. 11, 1913; Sept. 12, 1913; Sept. 14, 1915; Sept. 15, 1909; Sept. 17, 1913; Sept. 17, 1915; Sept. 22, 1910; Sept. 23, 1908; Sept. 24, 1917; Oct. 24, 1907; Oct. 24, 1910; Nov. 4, 1914; Nov. 12, 1911; and then again: May 21, 1909; May 22, 1909; May 23, 1914; May 25, 1914; July 5, 1909; July 10, 1908; July 23, 1907.

Eggs have been found in August (earliest date Aug. 13). In September and October specimens with glochidia are present, and then again in May. But all three records in July refer to specimens with glochidia. Thus the breeding season lasts from about the middle of August to the end of July, and may overlap with the next, or there may be a short interval at the end of July and in the first half of August. Surber found glochidia in September, October, November, in March, April, and May, and then again in July, which agrees well with my records. The species is *bradytictic.*

*Remarks: Eurynia recta* generally is easily recognized by its large size, elongated shape, and almost black color. However, young male specimens sometimes resemble *Elliptio dilatatus,* but may be distinguished by the shining, green-black epidermis, with indistinct, broad rays (if such are at all visible). *Elliptio dilatatus* has a dull, more brownish-black epidermis, with fine rays (if such are at all visible). The posterior end of *E. recta* is also more pointed, and the nacre is generally not so deeply colored as in *E. dilatatus.* There are additional differences in the hinge-teeth and the beak-sculpture. The female shell of *E. recta* cannot be confounded with *E. dilatatus.*

*Eurynia recta* is not very variable. The proportion of length and height varies slightly, and so does the color of the epidermis and of the nacre. In Lake Erie there is a local form, which differs from the Ohio type by its smaller size, its paler epidermis (browner, inclinding to russet), and more regular growth-lines. But there are specimens in the lake, chiefly younger ones, which are indistinguish-

able from specimens from the Ohio River. Therefore I do not think it advisable to separate the two forms by varietal names.[182] Specimens from Maumee River are entirely normal, *i.e.*, like the Ohio-form.

*Localities in Pennsylvania represented in the Carnegie Museum:*

*Ohio-drainage:*

Ohio River, Shippingport, Cook's Ferry, and Industry, Beaver Co.; Neville Island, Allegheny Co.; Edgeworth, Allegheny Co. (G. H. Clapp).

*Allegheny-drainage:* [183]

Allegheny River, Schenley, Aladdin, Godfrey, White Rock (Johnetta), Kelly, Mosgrove, and Templeton, Armstrong Co.; Walnut Bend, Venango Co.; Tionesta and Hickory, Forest Co.; Warren, Warren Co.

Crooked Creek, Rosston, Armstrong Co.

French Creek, Utica, Venango Co.; Cochranton, Meadville, and Cambridge Springs, Crawford Co.

Connewango Creek, Russell, Warren Co. (Dr. R. R. Jones).

*Monongahela-drainage:*

Monongahela River, Charleroi, Washington Co. (G. A. Ehrmann).

Dunkard Creek, Wiley, Greene Co.

Cheat River, Cheat Haven, Fayette Co.

*Lake-drainage:*

Lake Erie, Presque Isle Bay, and beach-pools of Presque Isle, Erie, Erie Co.

*Other localities represented in the Carnegie Museum:*

*Lake-drainage:*

Severn River, Gloucester Pool, Muskoka Co., Ontario, Canada (O. A. Peterson).

Lake Erie, Port Rowan, Norfolk Co., Ontario, Canada (C. Goodrich); Cedar Point, Erie Co., Ohio (C. Brookover); La Plaisance Bay, Monroe Co., Michigan (C. Goodrich).

Maumee River, Waterville, Lucas Co.; and Otsego Rapids, Wood Co., Ohio (C. Goodrich).

*Ohio-drainage:*

Tuscarawas River, Ohio (Holland collection).

Ohio River, Congo, Hancock Co., West Virginia; Toronto, Jefferson Co., Ohio; St. Marys, Pleasants Co., West Virginia; Parkersburg, Wood Co., West Virginia; Portland, Meigs Co., Ohio.

Cheat River, Jaco and Mont Chateau, Monongalia Co., West Virginia.

Little Kanawha River, Grantsville, Calhoun Co., West Virginia (W. F. Graham).

Elk River, Shelton and Clay, Clay Co.; Gassaway, Braxton Co., West Virginia.

Levisa Fork Big Sandy River, Prestonsburg, Floyd Co., Kentucky.

[182] It should be borne in mind that the original *recta* of Lamarck is from Lake Erie, and was subsequently called *sageri* by Conrad (See Walker, 1913, p. 21). The name *recta* should be retained for the lake-form, while for the form from the Ohio the varietal name *latissima* Rafinesque is available.

[183] In addition it may be stated that dead shells have been seen, but not taken, in the Conemaugh River, New Florence, Westmoreland Co.

*Tennessee-drainage:*

Paint Rock River, Paint Rock, Jackson Co., Alabama (H. H. Smith).

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith); Concord and Knoxville, Knox Co., Tennessee.

French Broad River, Boyd Creek, Sevier Co., Tennessee.

Nolichucky River, Chunns Shoals, Hamblen Co., Tennessee.

Holston River, McMillan and Mascot, Knox Co.; Hodges, Jefferson Co.; Turley Mill, Nocton, and Holston Station, Grainger Co., Tennessee.

North Fork Holston River, Rotherwood, Hawkins Co., Tennessee.

Clinch River, Solway, Knox Co.; Edgemoor, Clinton, and Offutt, Anderson Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Clinchport, Scott Co., Virginia; St. Paul, Wise Co., Virginia.

Powell River, Combs, Claiborne Co., Tennessee.

*Mississippi-drainage and westward:*

Kaskaskia River, Illinois (G. H. Clapp, donor).

Mississippi River, Muscatine, Muscatine Co., Iowa (Hartman collection); Moline, Rock Island Co., Illinois (P. E. Nordgren).

Kishwaukee River, Rockford, Winnebago Co., Illinois (P. E. Nordgren).

Meramec River, Meramec Highlands, St. Louis Co., Missouri (N. M. Grier).

James River, Galena, Stone Co., Missouri (A. A. Hinkley).

White River, Cotter, Baxter Co., Arkansas (A. A. Hinkley).

Black River, Black Rock, Lawrence Co., Arkansas (H. E. Wheeler).

Saline River, Benton, Saline Co., Arkansas (H. E. Wheeler).

Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).

Neosho River, Miami, Ottawa Co., Oklahoma (F. B. Isely).

*Alabama-drainage:*

Coosa River, Wilsonville, Shelby Co.; Riverside, St. Clair Co., Alabama (H. H. Smith).

Chattooga River, Cedar Bluff, Cherokee Co., Alabama (H. H. Smith).

*Distribution and Ecology in Pennsylvania* (See fig. 29): *Eurynia recta* is found in Pennsylvania in Lake Erie and in the Ohio-drainage. In the latter it distinctly prefers the larger rivers, where it is generally abundant, and attains a huge size. In the Allegheny it goes up to Warren County. Yet it has also entered some of the smaller tributaries. It is found in the lower part of Crooked Creek, in French Creek (up to Cambridge Springs), and in Connewango Creek. It also must have gone up the Kiskiminetas, for dead shells have been seen in the Conomaugh at New Florence. In the Monongahela-drainage it is present in the lower part of Dunkard Creek, and it is in Cheat River, where it passes up into West Virginia. On the other hand, its total absence in the whole Beaver-drainage is most remarkable.

Its ecological preferences show that it is mainly a form of the big rivers. In the Ohio it belongs chiefly to the shell-banks in the deep channel of the river with

gravelly bottom and strong, steady currents. In smaller streams it is also mostly in very strong currents and in heavy gravel on riffles. It buries very deeply. In Lake Erie it is found in the fine sand and gravel of Presque Isle Bay, in protected locations (among rushes) as well as on open, surf-beaten shores. It is also in some of the beach-pools with quiet water and sandy-muddy bottoms.

*General distribution: Type locality,* Lake Erie (Lamarck).

The metropolis of *E. recta* is in the large rivers of the central basin. From western Pennsylvania, it spreads all through the Ohio-drainage in Ohio (Sterki, 1907*a*), Indiana (Call, 1896*a*, 1900), in West Virginia, and eastern Kentucky. From the rest of Kentucky records are lacking, but it is in the Cumberland (Marshall, 1895; Wilson & Clark, 1914), and in the Tennessee, where it ascends in the Clinch River to Virginia. It is common in the Mississippi-drainage in Illinois (Baker, 1906), Iowa (Pratt, 1876; Witter, 1878; Call, 1895; Marshall, 1895; Geiser, 1910), and northward to Wisconsin (Conrad, 1836; Cooper, 1855; Lapham, 1860), and Minnesota (Cooper, 1855; Grant, 1886; Holzinger, 1888).

In the Missouri-drainage, it is found in Missouri (Utterback, 1916), in northeastern Kansas (Scammon, 1906), and southeastern Nebraska (Tryon, 1868; Call, 1895). Southward it becomes less abundant, but is known from the southern drainage in Kansas (Scammon), Arkansas (Call, 1895; Marshall, 1895; Wheeler, 1918), and Oklahoma. Its presence in Texas is doubtful.

In addition this species has crossed over into other drainages in the north as well as in the south. From northern Indiana and Ohio it has reached the lake-drainage in Michigan (Walker, 1898) and Lake Erie (Walker, 1913), and has spread down the St. Lawrence far into eastern Canada, Ottawa, Quebec, Montreal (See Bell, 1859; Whiteaves, 1863; Call, 1885; Marshall, 1895) and has entered some of the tributaries of the St. Lawrence in western New York (Marshall, 1895). In Ontario it goes northwest at least to the region of Georgian Bay, Severn River (See Carnegie Museum). Further in Minnesota it has crossed over into the drainage of the Red River of the North, Wilkin County (Grant, 1886), and has reached North Dakota, at Pembina (Call, 1885) and Roseau River (Dawson, 1875), Winnipeg (Christy, 1855; and Hanham, 1899) Canada.

Finally it is found in the south in the Alabama-drainage in Alabama and Georgia (Conrad, 1836; Lewis, 1877; Call, 1885, 1895).

As has been said, it prefers larger rivers, and within the immense area indicated above, it may be missing in many of the smaller, and even medium-sized streams. Baker (1898*a*) records it from lakes and large rivers, on muddy bottoms, while Scammon (1906) says that it is found under a variety of conditions.

### Genus Lampsilis Rafinesque (1820).

Ortmann, 1912, p. 345; Simpson, 1914, p. 35.

Type *Unio ovatus* Say.

In Pennsylvania I distinguish seven species and three varieties, which are to be recognized as follows:

Key to the Species and Varieties of Lampsilis.

$a_1$. Shell subelliptical, elongated, considerably over one-and-a-half times as long as high.

- $b_1$. Shell more or less swollen; in the female greatly inflated and broader behind. Epidermis more or less smooth and shining, with the rays, when present, rather sharply defined.
  - $c_1$. Larger, greenish-yellow, with dark rays, colors bright. Growth-lines irregular and not very distinct. . . . . . . . . . *L. luteola*.
  - $c_2$. Smaller, pale yellowish, or pale brownish, rays not so dark, colors duller. Growth-lines generally distinct and regular. . . . . . . . . . *L. luteola rosacea*.
- $b_2$. Shell more or less compressed, in the female not so greatly inflated and broadened behind. Epidermis rough, and not shining, with the rays less sharply defined. . . . . . . . . . *L. radiata*.

$a_2$. Shell suboval or subelliptical, not elongated, rarely about one and a half times as long as high, generally shorter.

- $b_1$. Shell moderately thick, or even comparatively thin. Color of epidermis yellowish, greenish, or grayish olive, or dull brownish. Rays variable, but, when present, generally sharply defined.
  - $c_1$. Epidermis yellowish or greenish olive, more or less shining (dull only in old shells). Rays, when present, more or less sharply defined.
    - $d_1$. Epidermis more or less greenish, more or less shining; when yellowish, the rays cover most of the shell.
      - $e_1$. Rays absent or simple, broader or narrower, not much crowded. Shell rather large.
        - $f_1$. Shell larger, colors brighter, rays more sharply marked, when present, and rather dark.
          - $g_1$. A sharp posterior ridge present, and posterior slope truncate. . . . *L. ovata*.
          - $g_2$. No sharp posterior ridge, posterior slope not truncate. *L. ovata ventricosa*.
        - $f_2$. Shell smaller, colors duller and paler, rays less distinct and not very dark. *L. ovata canadensis*.
      - $e_2$. Rays always present, fine, rarely somewhat broad, much crowded, and more or less interrupted or wavy. Shell of smaller size. . . . . . . . . . *L. fasciola*.
    - $d_2$. Epidermis bright yellow (wax-yellow), sometimes inclining to reddish brown, very bright and glossy. Rays, if present, very distinct, but generally restricted to the posterior part of the shell. . . . . . . . . . *L. cariosa*.
  - $c_2$. Epidermis dull in color, grayish olive, not very shining. Rays ill-defined. . . . . . *L. ochracea*.
- $b_2$. Shell very thick and heavy. Color of epidermis more or less reddish-yellow or brown. Rays indistinct. . . . . . . . . . *L. orbiculata*.

LAMPSILIS LUTEOLA (Lamarck) (1819).

*Lampsilis luteola* (LAMARCK) SIMPSON, 1914, p. 60.

Plate XVII, figs. 1, 2.

*Records from Pennsylvania:*

Clapp, 1895 (Allegheny Co.)
Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co.; Beaver, River, Wampum, Lawrence Co.)
Ortmann, 1909*b*, p. 190, 202.

*Characters of the shell:* Shell from medium size to rather large, moderately thick. Outline subelliptical or subovate, moderately elongated, distinctly over one-and-a-half times as long as high, but less than twice as long as high. Anterior margin rounded. Lower margin more or less regularly curved. Upper margin nearly straight, forming with the posterior margin a blunt angle, when young, or passing gradually into it, when old. Posterior margin meeting the lower margin in a very blunt angle, so that the posterior end of the shell is rather rounded off. Beaks low, located in the anterior portion of the shell. Beak-sculpture (see Marshall, 1890, fig. 3) fine, consisting of six to ten double-looped bars, with a distinct re-entering angle in the middle. The posterior loop is slightly angular, and indistinct upon the posterior slope. Sometimes the first bar appears subconcentric. Valves more or less swollen, rarely subcompressed, but flattened upon the sides. Posterior ridge indistinct.

Epidermis yellowish to light greenish, or light brownish, shining and smooth. In old shells it is darker, but not blackish. Rays are generally present. They are dark green to blackish, quite distinct, straight, narrow or broad, covering more or less of the surface. Posterior slope often darker in color, and less shining. Growth-rests more or less distinct, but irregular.

Hinge well-developed. Pseudocardinals two in left, one or two in right valve, tooth-like, compressed or stumpy, crenulated, very variable. Interdentum absent. Lateral teeth long, but rather thin, gently curved. Beak-cavity shallow. Dorsal muscle-scars in beak-cavity. Adductor-scars distinct and well impressed, chiefly the anterior one. Nacre milky-white, silvery, somewhat iridescent behind.

Sexual differences very strongly marked. While the male shell uniformly tapers backward to the bluntly pointed end, having the lower margin rather evenly curved, the female develops a considerable swelling and expansion of the lower margin in the postbasal region, so that the anterior part of the lower margin is nearly straight (or even slightly concave), and the posterior section of it ascends very suddenly to the posterior end. This produces a considerable widening of the posterior end of the shell, which often appears truncated. In old females this feature is so prominent, that the shell actually seems to be distorted.

| | | L. | H. | D. |
|---|---|---|---|---|
| *Size:* (Males) | 1. Linesville, Cat. No. 61.4027 | 142 mm. | 78 mm. | 60 mm. |
| | 2. Jamestown, Cat. No. 61.3453 | 125 " | 69 " | 54 " |
| | 3. Rosston, Cat. No. 61.4036 | 78 " | 45 " | 23 " |
| (Females) | 4. Linesville, Cat. No. 61.4027 (gravid) | 111 " | 73 " | 60 " |
| | 5. Wampum, Cat. No. 61.2873 | 101 " | 68 " | 41 " |
| | 6. Shenango, Cat. No. 61.4100 (gravid) | 71 " | 46 " | 26 " |

The maximum length given by Baker (1898*a*) is 116 mm., by Scammon (1906), 136 mm. Thus it is seen that the Pennsylvanian specimens attain an extreme size.

*Soft parts* (See Ortmann, 1912, p. 348). *Glochidia* (See Lea, Obs. VI, 1856, Pl. 5, fig. 10; Surber, 1912, Pl. 2, fig. 15). My measurements are: 0.23 × 0.28, while Surber gives: 0.250 × 0.290 mm. But Surber remarks (1912, p. 4) that at certain localities, the glochidia are uniformly smaller than at others.

*Breeding season:* My dates for gravid females are very numerous, and cover the periods from August 3 to October 27, and from April 22 to July 19. The

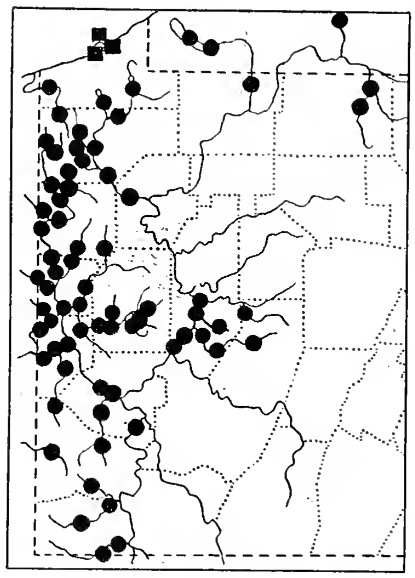

FIG. 30.

● *Lampsilis luteola.*

■ *Do. var. rosacea.*

species is *bradytictic*, but found gravid nearly all the year round, except in July, where there seems to be a short interim. Although gravid (and discharging) females have been found in July, they are rare in this condition in that month.

*Remarks:* A very variable species, but recognized by its subelongated shape, the light color of the epidermis, which is shining, and has generally well-marked

rays. Young specimens of *Actinonaias ligamentina* sometimes resemble this species, but their shape is more broadly elliptical. Large individuals of *Eurynia iris* also might be mistaken for *L. luteola*, but they have a more elongated shape, more iridescent nacre, and besides the character of the rays is different.

In old specimens the epidermis is often more or less discolored, and the smoothness disappears, but specimens with dark (brown or black) epidermis are very rare. The typical inflation of the valves is best developed in old individuals, while young ones are generally more or less compressed.

Several forms (or species) have been distinguished. The variety *rosacea* will be discussed below. But there are other local forms, which, however, are not constant enough to deserve special mention, and most of them are not found in our state.

*Localities in Pennsylvania represented in the Carnegie Museum:*

*Ohio River and Ohio-drainage:*

Ohio River, Cooks Ferry and Industry, Beaver Co.; Coraopolis (S. N. Rhoads) and Neville Island, Allegheny Co.

Buffalo Creek, Acheson, Washington Co.

Little Beaver Creek, Cannelton (Miss Vera White & H. H. Smith), Darlington, and New Galilee, Beaver Co.; Enon Valley, Lawrence Co.

Raccoon Creek, Raccoon Township, and New Sheffield, Beaver Co.; Bavington, Washington Co.

Chartiers Creek, Carnegie, Allegheny Co. (D. A. Atkinson & J. L. Graf).

Little Chartiers Creek, Morganza, Washington Co.

*Beaver-drainage:*

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).

Connoquenessing Creek, Zelienople and Harmony, Butler Co.

Slipperyrock Creek, Wurtemberg and Rose Point, Lawrence Co.

Wolf Creek, Grove City, Mercer Co.

Brush Creek, Celia, Beaver Co.

Little Connoquenessing Creek, Harmony, Butler Co.

Glade Run, Zeno, Butler Co.

Thorn Creek, McBride, Butler Co.

Bonnie Brook, East Butler, Butler Co.

Mahoning River, Mahoningtown, Coverts, Edinburg, and Hillsville, Lawrence Co.

Neshannock Creek, Volant, Lawrence Co.; Leesburg, Mercer Co.

Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Sharpsville, Clarksville, Shenango, and Jamestown, Mercer Co.; Linesville, Crawford Co.

Pymatuning Creek, Pymatuning Township, Mercer Co.

Little Shenango River, Greenville, Mercer Co.

Randolph Run, Hartstown, Crawford Co.

Padan Creek, Linesville, Crawford Co. (O. E. Jennings).

*Allegheny-drainage:*

Allegheny River, Johnetta, Kelly, Mosgrove, and Templeton, Armstrong Co.; Larabee, McKean Co. (Dennis Daily).

Crooked Creek, Rosston and South Bend, Armstrong Co.; Creekside, Indiana Co.

Cowanshannock Creek, Rural Valley, Armstrong Co. (N. M. Grier).

Little Mahoning Creek, Goodville, Indiana Co.

French Creek, Utica, Venango Co.; Cochranton, Meadville, and Cambridge Springs, Crawford Co.

Conneaut Outlet, Conneautlake, Crawford Co.

Conneaut Lake, Crawford Co.

Cussewago Creek, Mosiertown, Crawford Co. (H. & L. Ellsworth).

Conneauttee Creek, Edinboro, Erie Co.

Leboeuf Creek, Waterford, Erie Co.

Connewango Creek, Russell, Warren Co.

Potato Creek, Smethport, McKean Co. (P. E. Nordgren).

*Monongahela-drainage:*

Monongahela River, Elizabeth, Allegheny Co. (D. A. Atkinson).

Ten Mile Creek, Clarksville, Greene Co.; Amity, Washington Co.

South Fork Ten Mile Creek, Clarksville and Waynesburg, Greene Co.

Dunkard Creek, Wiley and Mount Morris, Greene Co.

*Lake Erie-drainage:*

Conneaut Creek, Springboro, Crawford Co.; West Springfield, Erie Co.

### *Other localities represented in the Carnegie Museum:*

*Lake-drainage:*

Genesee River, Rochester and Chili, Monroe Co., New York (R. H. Santens).

Black Creek, Chili, Monroe Co., New York (R. H. Santens).

Conestogo River, Conestogo, Waterloo Co., Ontario, Canada (Miss Maria Jentsch).

Creek at North Fairfield, Huron Co., Ohio (O. E. Jennings).

Sandusky River, Upper Sandusky, Wyandot Co., Ohio (C. Goodrich).

Cedar Creek, Jerusalem Township, Lucas Co., Ohio (C. Goodrich).

Swan Creek, Toledo, Lucas Co., Ohio (C. Goodrich).

Maumee River, Roche de Boeuf Rapids, Lucas Co., Ohio (C. Goodrich).

St. Marys River, Rockford, Mercer Co., Ohio (C. Goodrich).

Blanchard River, Findlay, Hancock Co., Ohio (C. Goodrich).

Silver Creek and Beaver Creek, Williams Co., Ohio (C. Goodrich).

Ten Mile Creek, Toledo, Lucas Co., Ohio (C. Goodrich).

Otter Creek, La Salle Township, Monroe Co., Michigan (C. Goodrich).

Raisin River, Adrian, Lenawee Co.; Grape P. O., Monroe Co., Michigan (C. Goodrich).

Long Lake, Fenton, Genesee Co., Michigan (C. Goodrich).

*Ohio- and Mississippi-drainage:*

Chautauqua Lake, Chautauqua Co., New York.[184]

Mahoning River, Leavittsburgh, Trumbull Co., Ohio (Smith collection).

[184] I have numerous specimens collected by R. Foerster, D. Brown, D. R. Sumstine, P. E. Nordgren, and Miss B. Ortmann, from various localities in the lake. They represent a somewhat *dwarfed* form, which in this respect resembles the var. *rosaeca*, but agrees in other respects with typical *luteola*.

West Branch Nimishillen Creek, Canton, Stark Co., Ohio.
Tuscarawas River, Ohio (Holland collection).
Wolfe Creek, Wolfe Creek P. O., Washington Co., Ohio (W. F. Graham).
Scioto River, Kenton, Hardin Co., Ohio (C. Goodrich).
Ohio Canal, Columbus, Franklin Co., Ohio (Smith collection).
Ohio River, Toronto, Jefferson Co., Ohio.
West Fork River, Lynch Mines, Harrison Co.; Lightburn and Weston, Lewis Co., West Virginia.
Little Kanawha River, Burnsville, Braxton Co., West Virginia.[185]
North Fork Hughes River, Cornwallis, Ritchie Co., West Virginia.
Pocatalico River, Raymond City, Putnam Co., West Virginia.
Coal River, Sproul, Kanawha Co., West Virginia.
Mud River, Milton, Cabell Co., West Virginia.
Licking River, Farmer, Rowan Co., Kentucky.[186]
Muscatine Slough, Muscatine, Muscatine Co., Iowa (Hartman collection).
Mississippi River, Moline, Rock Island Co., Illinois (P. E. Nordgren).
Kishwaukee River, Rockford, Winnebago Co., Illinois (P. E. Nordgren).

*West of Mississippi:*

Kansas River, Lawrence, Douglas Co., Kansas (R. L. Moodie).
Bull Creek, Miami Co., Kansas (C. Goodrich, donor) (Osage-drainage).
Spring River, Williford, Sharp Co., Arkansas (H. E. Wheeler).
Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).[187]
Fourteen Mile Creek, McBrides Switch, Wagoner Co., Oklahoma (F. B. Isely).[187]

*Distribution and Ecology in Pennsylvania* (See fig. 30): This is a common species in western Pennsylvania, although not found everywhere. It is averse to large rivers, and, if at all present in them, is either rare, or is found under special conditions, in smaller branches of the main river (as for instance at Neville Island). On the other hand, it is very abundant in some of the smaller streams, as for instance, in the whole Beaver-drainage. It avoids certain streams, and this is especially true of mountain-streams, such as Cheat River and the Kiskiminetas-drainage.[188] It occurs in the only tributary of Lake Erie, in our state, which contains shells (Conneaut Creek).

[185] I have seen this species in Oil Creek, Orlando, Lewis Co., West Virginia.

[186] I have also seen specimens in Fleming Creek, Pleasant Valley, Nicholas Co., Kentucky.

[187] Some specimens from Ouachita River and from Oklahoma are quite typical, but Wheeler (1918, p. 117) does not report *L. luteola* from Clark Co., Arkansas. In this region peculiar forms turn up, some of which develop reddish color in the nacre, and others intergrade in the direction of *L. hydiana* (Lea). I omit these since I have not enough material to clear up their affinities.

[188] The fauna of this system is poorly known. However, remarkably enough, this species has not been listed by Harn (1891), whose material seems to have come chiefly from the Kiskiminetas-Conemaugh-drainage. This serves to substantiate the above conclusion, since I never found this species in the two creeks of this region, where I have been able to collect the fauna (upper Loyalhanna and Quemahoning). Also in Yellow and Two Lick Creeks, where a fragmentary fauna has been observed, this species was not present.

Ecologically this species is found under a number of conditions, but there is no doubt that it prefers rather quiet water and sandy-muddy bottoms. Strong currents and rough bottoms do not suit it, and although occasionally found in riffles, it probably has in such cases been washed out of the quieter pools. In the quiet water below riffles, where there is more or less muddy bottom, or in slowly running water with fine gravel, sand, and mud, it is abundant. This accounts for its absence in mountain-streams, and its absence or scarcity in the large rivers, while its most favorable localities are in the plateau-streams, or the streams within the glacial drift, which are more sluggish and have finer bottom material. For this reason, this species is also much inclined to go into lakes.

*General distribution: Type locality,* According to Lamarck this species comes from the Susquehanna and Mohawk Rivers. Its presence in the Susquehanna has never been confirmed, but in the Mohawk it has been found subsequently (Lewis, 1860; Marshall, 1895), and also at other places in the Mohawk and Hudson drainages, as well as in the Erie Canal (DeKay, 1843; Simpson, 1891; Marshall). The *Mohawk* should be designated as the type-locality. This is in the Atlantic-drainage, but the chief distribution of this species is in the Interior basin.

In New York it is also known from the St. Lawrence-drainage (Marshall, 1895), and material in the Carnegie Museum from the Genesee system shows that it is the typical *luteola,* which is found there. It is also found in New York in the Ohio-drainage, in Ischua Creek, Cattaraugus Co., and Lake Chautauqua (Marshall). How far the typical form extends northward in this region is unknown. It has been reported from Canada (Ontario, and also westward in the St. Lawrence-drainage up to Lake Superior, and from the Hudson Bay-drainage) but in these northern parts it seems, that its place is largely, if not entirely, taken by certain varieties, chiefly *rosacea* (See below). Yet the typical form is certainly present north of Lake Erie as is shown by specimens in the Carnegie Museum (Conestogo River) (also reported from northern Michigan, in Manistique River, Schoolcraft Co., by Winslow, 1917).

Westwards *L. luteola* is found practically all over western Pennsylvania, Ohio, Indiana, and Illinois, crossing over into the lake-drainage at various points, and it extends northward through Iowa, Wisconsin, and Minnesota into the drainage of the Red River of the North, although, as has been said, it seems in the northern parts of its range to give way to varieties.

Lewis (1877) calls attention to the fact that this species has not been recorded from "any stream much south of the latitude of the Ohio River," but that possibly it is present in Kentucky. Material in the Carnegie Museum shows that it occurs

in West Virginia not only in the headwaters of the Monongahela, but also in the Little Kanawha, in the Kanawha and Guyandotte drainages; but that it is absent here in certain regions, for instance, in the Elk River of the Kanawha system. This no doubt is due to the rough character of Elk River. In addition I found this species in the Licking River in Kentucky. But it actually seems to be absent in the Cumberland and Tennessee River drainages.

In a westward and southwestward direction this species undoubtedly goes as far as Missouri (Utterback, 1916), Kansas (Scammon, 1906), Arkansas, and Oklahoma, and has been reported to exist in Texas (Brazos River, Simpson, 1900). However, in this region it passes into other forms (*hydiana*, for instance) which may, or may not be, "good species." In Mississippi and Alabama it seems to be represented by kindred forms, which are generally considered to be different species.

Thus *L. luteola* has its main range chiefly in the northern section of the Interior Basin, north of the Ohio, and passes into the northern drainages of the St. Lawrence and Hudson Bay. But in the north, as well as in the south, it inclines to variation, and has developed geographical and local races, some of which may be regarded as valid species.

Both Baker (1898*a*) and Scammon (1906) call this a mud-loving species, which agrees with my observations. Although sometimes found in other environment, it thrives best and is most abundant in mud and sluggish or quiet water. This satisfactorily explains its absence in certain streams in western Pennsylvania and West Virginia, and possibly also in the Tennessee-Cumberland-drainage. This also holds good in the Ohio River between Pennsylvania and Cincinnati. I found it in the Ohio at Toronto, in a small branch of the river, but at no other locality, and it was entirely missing in the numerous piles of the clam-diggers examined by myself.

### Lampsilis luteola rosacea (DeKay) (1843).

*Lampsilis luteola rosacea* (DeKay) Simpson, 1914, p. 62; Walker, 1913, p. 21.

Plate XVII, figs. 3, 4, 5.

*Record from Pennsylvania:*

Ortmann, 1919*b*, p. 202 (as lake-form of *L. luteola*).

*Characters of variety:* This may be described as a small, stunted form of *L. luteola*, generally with rather light-colored (pale yellow to rusty) epidermis, with white or (locally) rosaceous nacre. The specimens from Lake Erie (and also other lakes) have generally more regular, more crowded, and more distinct growth-rests.

| | | | L. | H. | D. |
|---|---|---|---|---|---|
| *Size:* | (Males) | 1. Erie, Cat. No. 61.4858 | 89 mm. | 49 mm. | 31 mm. |
| | | 2. do. Cat. No. 61.4020 | 76 " | 44 " | 27 " |
| | | 3. do. Cat. No. 61.4020 | 51 " | 29 " | 18 " |
| | (Females) | 4. Erie, Cat. No. 61.4020 (gravid) | 81 " | 54 " | 35 " |
| | | 5. do. Cat. No. 61.4020 (gravid) | 64 " | 41 " | 28 " |
| | | 6. do. Cat. No. 61.4860 | 52 " | 34 " | 20 " |

*Soft parts* identical with those of the main species, *glochidia* also identical.

*Breeding season:* Gravid females are on record for May 21, 1909; May 22, 1909; May 24, 1909; July 7, 1910; July 12, 1910. All these specimens had glochidia, and on July 7 and 12 a number were observed discharging the glochidia. The variety is certainly *bradytictic,* like the main species.

*Remarks:* The original description of *rosaceus* DeKay is founded upon specimens with special features: rosy nacre and pallid brown epidermis. But Simpson (1900, p. 535, footnote 1) pointed out that this probably is only a local effect, and that other specimens have white nacre and differently colored (darker) epidermis.[189] I find, that there is in Lake Erie great uniformity in the color of the nacre, which is always white, while there is great variability in the color of the epidermis. Specimens from the surf-beaten shores of the open lake are remarkably light, and the ground color of the epidermis is light yellow or light greenish (grayish-green), while those from protected localities in Presque Isle Bay, and from beach-pools, are more greenish-olive, lighter or darker, and often incline toward a reddish brown, which is most intense and brilliant towards the beaks. In the growth-lines there is great variability, but the tendency is to have them rather closely set, rather distinct and regular. This is most evident in specimens from deeper water, least so in those from the beach-pools.

The characters of this variety are very poorly marked. It is true that specimens from Lake Erie generally are recognizable by size, color, and distinct growth-lines; but in specimens from other localities these characters are more or less unstable, and transitional conditions toward true *luteola* are frequent. I have already mentioned that in *L. luteola* from Lake Chautauqua, which incline toward *rosacea* in size, other characters are normal. Specimens from Winona Lake look much like the Lake Erie form, having the reddish epidermis and very distinct growth-lines, but are larger. Specimens from Moose River are small and pale in color, but the growth-lines are indistinct.

Specimens collected by O. E. Jennings on the North shore of Lake Superior much resemble the Lake Erie form, being pale in color, without rays, but they differ

[189] Utterback (1916, p. 185) relying only on the color of the nacre, erroneously called the red-nacred form of Missouri (also found in Arkansas) by the name of *L. luteola rosaceus.*

in different localities. A specimen from Nipigon Straits is absolutely like the Lake Erie form, while others from Six Mile Lake (a shallow lake on Thundercape Peninsula) have irregular growth-lines, and incline more toward normal *luteola*. These specimens could not very well be called *superiorensis*, for they do not have a dark epidermis. Then again specimens from Kaministiquia River (tributary to Lake Superior at Fort William) are darker in color, and might possibly represent the real *superiorensis*.

Specimens from Sheyenne River, North Dakota, are indistinguishable from certain Lake Erie specimens, except for the irregular growth-lines.

I have the impression that *rosacea* is not so much a geographical, as an ecological race, produced by the environment of great lakes, and that it turns up, whenever the proper conditions are offered. Since this environment is very widely distributed in the northern states and in Canada, *rosacea* appears as a geographical race. In this connection it should be emphasized that this variety is not found in the tributaries of the lakes, but that the normal form of *luteola* exists there. There are also certain lakes, in which the form *rosacea* is not present, for instance Lake Chautauqua, and Conneaut Lake. In the latter *luteola* is quite typical.

More detailed investigations are required to finally determine this question. It also should be ascertained to what factors the rose-colored nacre may be due. Our specimens from Sandy Lake, Ontario, have red nacre, and come from a lake, the water of which is, according to Mr. G. H. Clapp, heavily charged with lime.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Lake Erie, Presque Isle Bay, outer shore, and beach-pools of Presque Isle, Erie, Erie Co.

*Other localities represented in the Carnegie Museum:*

Lake Ontario, Braddock Bay, Manitou Beach, Monroe Co., New York (R. H. Santens).

Lake Erie, Sandusky Bay, Cedar Point, Erie Co., Ohio (C. Brookover) (O. E. Jennings); La Plaisance Bay, Monroe Co., Michigan (C. Goodrich); Crystal Beach (F. Behrle) and Port Colborn, Welland Co. (C. Goodrich); Port Rowan and Port Dover, Norfolk Co., Ontario, Canada (C. Goodrich).

Sandy Lake, Peterboro Co., Ontario, Canada (G. H. Clapp).

Grand River, Cayuga, Haldimand Co., Ontario, Canada (C. Goodrich).[190]

Winona Lake, Kosciusko Co., Indiana (E. B. Williamson) (not typical).

Lake Wiwassee, Kosciusko Co., Indiana (C. Goodrich).

Lake Huron, Port Huron, St. Clair Co., Michigan (N. M. Grier); Saginaw Bay, Michigan (Smith collection).

Big and Little Whitefish Lakes, Pierson, Montcalm Co., Michigan (Miss M. O'Malley).

Au Sauble Lakes, Lake Co., Michigan (C. Goodrich).

Douglas Lake, Cheboygan Co., Michigan (H. B. Baker).

[190] A small race of *luteola*, and probably var. *rosacea*, although not typical. It should be noted that in the Upper Grand River-drainage (Conestogo River), the real *L. luteola* is present.

Crystal Lake, Benzie Co., Michigan (B. Walker, donor).
Lake Michigan, off Kenosha, Kenosha Co., Wisconsin (P. E. Nordgren).
Lake Superior, Nipigon Straits, St. Ignace Island, Ontario, Canada (O. E. Jennings).
Six Mile Lake, Silver Island, Thundercape Peninsula, Ontario, Canada (O. E. Jennings).
Lake Nipigon, Ombabika Bay, Ontario, Canada (O. E. Jennings).
Sheyenne River, Argusville, Cass Co., North Dakota (S. M. Edwards).
Moose River, South of Moose Factory, Ontario, Canada (W. E. C. Todd).

*Distribution and Ecology* (See fig. 30): *Type locality*, Seneca Lake, New York (DeKay).

As Simpson says, this race is found in the St. Lawrence area, and is common in the lakes. However, its exact distribution is not very well known, since it often has not been kept apart from the typical form. In addition our records show, that, in northern Indiana, it is also in some lakes belonging to the Ohio (Wabash) drainage.

Walker (1913) has it from Lake Erie, and he was the first to use the name *rosacea* for the lake-form. Sterki (1907*a*) reports it from Lake Erie in Ohio, but he also gives typical *luteola* from this lake. It may be, that he understood by *rosacea* only specimens with red nacre. But I have never seen such from Lake Erie. Walker (1898) reports *borealis* and *superiorensis* from northern Michigan, but not *rosacea*. What I have from Lake Huron and central and northern Michigan, is indistinguishable from the Lake Erie form. This variety certainly also occurs in Lake Michigan and Lake Superior.

A form very close to this is found in Moose River, near Hudson Bay. It also turns up again, although not quite typical, in the drainage of the Red River of the North in North Dakota.

The ecological preference of this form is certainly for the lake environment, and it is best developed in the larger lakes. In Presque Isle Bay in Lake Erie, where it is a common shell, it is found everywhere on the sandy and gravelly shores, in shallow water, and down to a depth of about fifteen feet in sand and mud. It also is found in the beach-pools of Presque Isle, upon sandy-muddy bottom, and is one of the few shells existing in the open lake, being frequently thrown out alive by the surf.

### Lampsilis radiata (Gmelin) (1792).

*Lampsilis radiata* (Gmelin) Simpson, 1914, p. 64.[191]

Plate XVII, figs. 6, 7.

*Records from Pennsylvania:*

Gabb, 1861 (Schuylkill and Wissahickon, and League Island, Philadelphia).
Bruckhart, 1869 (Lancaster Co.)

[191] The figures given by DeKay (1843, Pl. 19, figs. 237, 238) as of *Unio ochraceus*, have always been taken for *L. ochracea* (Say), even by Simpson (1914, p. 50), but they actually represent *L. radiata*, and

Hartman & Michener, 1874 (Schuylkill River, Chester Co.).
Dean, 1891 (West Branch Susquehanna River, Muncy, Lycoming Co.).
Pilsbry, 1894 (Susquehanna River, York Furnace, York Co.).
Schick, 1895 (Delaware River, Philadelphia; Canal at Manayunk).
Ortmann, 1909*b*, p. 204.

*Characters of the shell:* Shell of about the same size and similar in shape to that of *L. luteola.* Beak-sculpture also similar (Marshall, 1890, fig. 4), but valves much more compressed. Epidermis yellowish, or light or dark green, more rarely inclining to brownish, not smooth, but roughened by close concentric wrinkles. Dark green or blackish rays are generally present, but they are not well-defined, except that in light-colored specimens they are sharper. Concentric bands of lighter and darker color are often present.

Hinge similar to that of *L. luteola,* as well as the rest of the inside of the shell, but the color of the nacre is more variable, sometimes being entirely white, often tinted with pinkish or salmon, and even entirely of these colors.

Sexual differences of the shell much less marked than in *L. luteola.* The female shell has a similar tendency to expand in the postbasal region, but only slightly, and never so distinctly as in *L. luteola.* Some females are even hard to distinguish from males.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Manayunk, Cat. No. 61.4051 (probably ♂) | 93 mm. | 53 mm. | 27 mm. |
| 2. do. Cat. No. 61.1789 (♀) | 88 " | 52 " | 28 " |
| 3. Tunkhannock, Cat. No. 61.4054 (gravid ♀) | 87 " | 49 " | 29 " |
| 4. Yardley, Cat. No. 61.3473 (probably ♂) | 71 " | 42 " | 21 " |
| 5. Selinsgrove, Cat. No. 61.4868 (♂) | 70 " | 40 " | 23 " |
| 6. South Waverly, Cat. No. 61.4053 (♀) | 60 " | 34 " | 17 " |

*Soft parts* (See Ortmann, 1912, p. 349) figured by Lea (Obs. II, 1838, Pl. 15, figs. 48, 49). *Glochidia* (See Lea, Obs. VI, 1858, Pl. 5, fig. 20). I observed them in a specimen from Severn River, Ontario. They agree with those of *L. luteola:* L. 0.22 to 0.23, H. 0.27 to 0.28 mm.

*Breeding season:* According to Conner (1907) "all the year round." I have taken a gravid female with eggs on Aug. 22, 1909. This would indicate the beginning of the season. The female with glochidia was collected Aug. 20, 1914. It might be that this represents the end of the breeding season, which thus would overlap with the next one.

are both probably females, which is seen at once by the general outline of the shell. It is remarkable, that this mistake of DeKay has never been discovered, although his error with reference to his *Unio radiatus* (which is *Eurynia iris novi-eboraci*) has been corrected previously. There is no doubt that the confusion within the two species, *radiata* and *ochracea,* is in large part due to these incorrectly named figures of DeKay.

*Remarks:* The distinctness of this species from *L. luteola* has been much discussed. Some writers (Dean, 1891) hold that it is sharply separated, while others, among them Simpson (1891), admit that there apparently are intergrades.

According to my experience I must say, that I never had in our state any trouble in distinguishing the two species. *L. radiata* is more compressed, lacks the shining epidermis, often has reddish nacre, and the difference between the male and the female shell is considerably less marked than in *L. luteola.*

But I possess a few specimens which indeed are somewhat abnormal. This applies chiefly to some I received from C. H. Conner, and which come from Newton Lake, Camden Co., New Jersey. These are more swollen than the normal form, and in the female the shell is more expanded in the postbasal region, and in shape they thus greatly resemble *L. luteola.* However, even in these specimens the epidermis has the fine wrinkles of *L. radiata,* and is not smooth and shining as it is in *L. luteola.* I think that these specimens represent the reaction of *L. radiata* to the lake-environment.

With respect to shape and principally color, this species appears to be quite variable outside of Pennsylvania, but within this state it is rather uniform. It seems to me that in the northern parts of its range lighter epidermis (yellow to light brown) prevails, while farther south darker tints (dark green to brownish) are the rule. In the extreme south (southern Virginia and North Carolina) this species seems to develop a distinct local race (var. *conspicua* (Lea)).

It should be mentioned, that *L. radiata* to a certain degree resembles *Actinonaias ligamentina* in general shape and color, and the dark green specimens with broad rays distinctly recall the latter species. Such specimens may be recognized by the more elongated shape, thinner shell, and by the rough epidermis. Likewise the presence of pink in the nacre, and the beak-sculpture serve to distinguish them.[192]

Of course, the examination of the soft parts always shows that these two species have no close genetic relationship.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Delaware River, Yardley, Bucks Co.
Schuylkill Canal, Manayunk, Philadelphia Co.
Susquehanna River, Selinsgrove, Snyder Co.
West Branch Susquehanna River, Williamsport, Lycoming Co. (D. A. Atkinson).
North Branch Susquehanna River, Tunkhannock, Wyoming Co.

[192] A specimen from Grand Rapids, Michigan, in the Carnegie Museum, was labeled *U. radiatus,* and, has indeed, much external resemblance to this. But closer inspection has shown that it is *Actinonaias ligamentina,* having the smooth epidermis and the beak-sculpture of this species.

Chemung River, South Waverly, Bradford Co.

*Other localities represented in the Carnegie Museum:*

Ottawa, Ontario, Canada (Hartman collection) (marked: " Lea datum ").
St. Lawrence River, Bluff Island, Clayton, Jefferson Co., New York (Miss A. H. Robinson) (H. Kahl); Grindstone Island, Clayton, Jefferson Co., New York (H. Kahl).[193]
Severn River, Gloucester Pool, Muskoka Co., Ontario, Canada (O. A. Peterson).
Spider Bay of Georgian Bay, Sans Souci, Parry Sound, Ontario, Canada (H. Kahl).
Connecticut River (Hartman collection).
Herkimer Co., New York (Smith collection).
Keuka Lake, Yates Co., New York (G. H. Clapp, donor) (Lake Ontario-drainage).
Little Lakes, Herkimer Co., New York (Smith collection).[194]
Newton Lake, Camden Co., New Jersey (C. H. Conner) (See above).
Delaware River, Newbold, Gloucester Co. (C. H. Conner); and Fish House, Camden Co., New Jersey.
Potomac River, Washington, D. C. (G. H. Clapp, donor).

*Distribution and Ecology in Pennsylvania* (See fig. 31): In Pennsylvania this species is found in the Delaware and Susquehanna drainages, but it is absent in

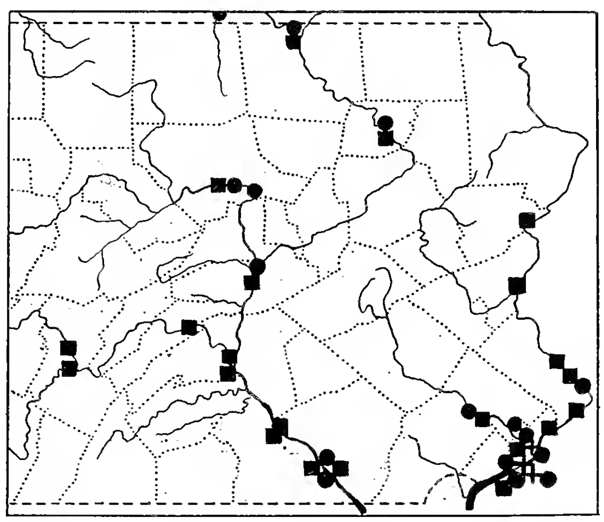

FIG. 31.
● *Lampsilis radiata.*
■ *Lampsilis cariosa.*
+ *Lampsilis ochracea.*

the smaller streams which flow to the Potomac. Altogether it is rare according to my experience, but this may be due to the fact that I did not do much collecting

[193] A dwarf form, with light brown ground-color of epidermis. These specimens might represent *U. borealis* Gray.

[194] This is in Herkimer Co., not in Otsego Co., as given by Lewis (1856, p. 259). These lakes drain into Otsego Lake, and this in turn into the Susquehanna River.

in the tidewaters of the Delaware. According to the older records, its metropolis seems to be in the lower Delaware near Philadelphia. It ascends the larger rivers (Delaware and Schuylkill), but the upper boundary has not been ascertained.

In the Susquehanna-drainage it is distinctly a rare shell. It has been found in the lower part (York Haven, Pilsbry), but otherwise it is restricted to its larger branches. In the West Branch it has been traced up to Williamsport, in the North Branch to the New York state line.[195]

Although present in the lower Potomac, it has never been found in the drainage of this river in Pennsylvania, and it seems to be absent in the whole upper Potomac system West of the Blue Ridge Mountain.

Having found this species only at a few places, and probably not in the most favorable environment, I am unable to say what are the ecological conditions, which it prefers. In the Delaware above Trenton and in the Susquehanna I found it in strongly flowing water in gravel. But here it was unquestionably rare. If its metropolis is in the lower parts of the large rivers, it might be a tidewater species, prefering quiet water, and sandy or muddy bottom. At any rate, I found it on sandy bottom in the lake-like part of the Delaware at Fish House, New Jersey.

*General distribution: Type locality,* Given by Gmelin from Malabar, which, of course, is incorrect. Lamarck (1819) reports it from Saratoga Lake in New York, and if there should not be any other earlier record, we might select this as the type locality. Simpson (1914) gives Virginia as type locality.

This species belongs to the Atlantic-drainage from Virginia to Maine. In Virginia it is chiefly present according to Conrad (1836) in the tidewaters,[196] and farther South it assumes a different shape, and has been called *conspicua.* Its presence in the lower Potomac in Virginia and the District of Columbia is well established (Dewey, 1856; Marshall, 1895). It is known from the state of Delaware (Rhoads, 1904), Pennsylvania, New Jersey (lower Delaware River, and Second River, Belleville, Essex Co., as *ochraceus* De Kay, 1843), from New York, Connecticut, Rhode Island, Massachusetts and Maine (See Linsley, 1845; Perkins, 1869; Gould-Binney, 1870; Carpenter, 1890; Lermond, 1909; Johnson, 1915). In New York (Marshall, 1895) it ascends the Atlantic rivers (Upper Susquehanna and Hudson) reaching the Mohawk, and crossing over into the St. Lawrence-drainage, where it is found in Lake Ontario and its tributaries, and down the

[195] It goes farther up in New York state, since it occurs in Little Lakes and Schuyler's Lake in the region of the headwaters, and has been reported from Chenango and Tioga Rivers.

[196] It is positively absent in the mountains west of the Blue Ridge, and also seems to be absent or rare on the Piedmont Plateau.

St. Lawrence to Ottawa and Montreal (Bell, 1859; Simpson, 1891; Marshall, 1895).

Possibly it extends its range westward from the lower St. Lawrence, for it has been reported from Lake Nipissing (Bell, 1859), and even farther West, from Lake Superior, Lake Winnipeg, and Nelson River, but these latter localities require confirmation, and a few additional records from Ohio and Indiana are certainly wrong. Its presence in Michigan is doubtful (Walker, 1898). But it is positively present in the region of Georgian Bay: specimens in the Carnegie Museum are nearly normal, except that the color is often more brownish.

This is an Atlantic species, belonging to the northern element in the Atlantic fauna (Ortmann, 1913*a*). In New York it has crossed over into the lower St. Lawrence-drainage, and apparently has here a tendency to spread westward along a route, which lies North of Lake Erie. If this should prove to be correct, attention should be called to the similarity of this range with that of *Elliptio violaceus*.

In New York its range in part overlaps that of *L. luteola* (certainly in the Mohawk and St. Lawrence drainages), but particulars as to the mutual relation and possible association of these two species are lacking. This is a question which requires closer investigation.

As far as known, this species prefers tidewaters, but ascends some of the larger rivers to a considerable distance (Hudson, Susquehanna). Nevertheless in the south it apparently does not have this tendency. The fact that it often goes into canals and is frequently found in lakes, also indicates that rough water and rough bottom (riffles) are not very favorable to it.

### Lampsilis ovata (Say) (1817).[197]

*Lampsilis ovatus* Simpson, 1914, p. 48.

Plate XVII, figs. 8, 9; Plate XVIII, figs. 1, 2, 3.

*Records from Pennsylvania:*

Call, 1885 (Allegheny River, up to central New York).
Clapp, 1895 (Allegheny Co.).
Marshall, 1895 (Allegheny River, Warren, Warren Co.).
Rhoads, 1899 (confused with *L. ovata ventricosa*, but specimens from Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co., belong here).
Ortmann, 1909*b*, p. 189.

*Characters of the shell:* For reasons given below, it is best to describe this form in terms of comparison with its variety, *L. ovata ventricosa* (See remarks).

[197] Not 1816.

Similar to *L. ovata ventricosa,* but distinguished by the development of the posterior ridge, which is very sharp and very distinct toward the beaks. In consequence of this the posterior slope is flattened, and in most cases even concave, chiefly towards the beaks. Further towards the anterior end of the shell the two valves are not uniformly convex, but peculiarly compressed, rendering the horizontal cross-section of this part wedge-shaped.

In addition there is a tendency toward the suppression of the rays. Rays are indeed sometimes present, but in most cases the epidermis is uniformly greenish yellow, dark upon the posterior slope and without rays. Old males become drawn out at the posterior end, almost rostrate.

| | | | L. | H. | D. |
|---|---|---|---|---|---|
| *Size:* | (Males) | 1. Aladdin, Cat. No. 61.3426 | 136 mm. | 92 mm. | 57 mm. |
| | | 2. Walnut Bend, Cat. No. 61.3423 | 103 " | 72 " | 46 " |
| | | 3. Godfrey, Cat. No. 61.4009 | 86 " | 61 " | 37 " |
| | (Females) | 4. Industry, Cat. No. 61.3425 | 126 " | 94 " | 64 " |
| | | 5. Cambridge Springs, Cat. No. 61.4010 (gravid) | 100 " | 81 " | 48 " |
| | | 6. Cochranton, Cat. No. 61.3420 | 83 " | 64 " | 39 " |

*Soft parts* (See Ortmann, 1912, p. 350, fig. 26). *Glochidia* (See Lea, Obs. VI, 1858, Pl. 5, fig. 15). I have found them to measure: $0.24 \times 0.28$ mm.

*Breeding season:* My records for gravid females cover the period from August 4 to October 24, and from May 23 to May 25. The spring records are scanty, but the species is surely *bradytictic,* and there is an interim at least in July.

*Remarks:* There are numerous intergrades between *L. ovata* and *L. ventricosa.* In the larger rivers, the two forms are practically always associated, and the transition from a very sharp to an almost entirely effaced posterior ridge with the corresponding intermediate condition of the posterior slope, is frequently found. Likewise the other characters given above pass into each other. In color there is also great variability, and, although the true *ovata* has generally no rays, rays are sometimes very well-developed; on the other hand in true *ventricosa* the rays may be lacking. I have quite a number of specimens, which are so completely intermediate, that I am unable to assign them to either form.

Going up beyond a certain point in our rivers, and into the smaller tributaries, *L. ovata* disappears, and its place is entirely taken by *L. ovata ventricosa,* and there are many creeks, where only the form *ventricosa* exists with no trace of *ovata,* and no indications of an inclination toward it.

Exactly the same conditions prevail in the upper Tennessee-drainage in eastern Tennessee and southwestern Virginia, and a form corresponding to *L. ovata ventricosa* develops out of the true *L. ovata* in the headwaters. However, the

Tennessee *ventricosa* has some peculiarities of its own. These shells will be treated elsewhere.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Ohio River, Industry, Beaver Co.; Coraopolis (S. N. Rhoads), Neville Island, and Edgeworth, Allegheny Co. (G. H. Clapp).

Allegheny River, Braeburn, Westmoreland Co.; Aladdin, Godfrey, Johnetta, Kelly, and Templeton, Armstrong Co.; Walnut Bend, Venango Co.; Tionesta and Hickory, Forest Co.; Warren, Warren Co.

French Creek, Cochranton, Meadville, and Cambridge Springs, Crawford Co.

Conneaut Outlet, Conneautlake, Crawford Co.

*Other localities represented in the Carnegie Museum:*

*Ohio-drainage:*

Ohio River, Toronto, Jefferson Co., Ohio; Wheeling, Ohio Co., West Virginia (W. F. Graham); St. Marys, Pleasants Co., West Virginia; Portland, Meigs Co., Ohio.

Elk River, Shelton and Clay, Clay Co., West Virginia.

*Tennessee-drainage:*

Tennessee River, Tuscumbia, Colbert Co., and Florence, Lauderdale Co., Alabama (H. H. Smith).

Paint Rock River, Paint Rock and Princeton, Jackson Co., Alabama (H. H. Smith).

Holston River, McMillan and Mascot, Knox Co.; Hodges, Jefferson Co.; Turley Mill and Holston Station, Grainger Co., Tennessee.

Clinch River, Solway, Knox Co.; Edgemoor, Clinton, and Offutt, Anderson Co.; Black Fox Ford, Union Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Clinchport, Scott Co., Virginia.

Powell River, Combs, Claiborne Co., Tennessee.

*Distribution and Ecology in Pennsylvania* (See fig. 32): This species is abundant in the Ohio below Pittsburgh, and in the Allegheny all the way up to Warren County. According to Call (1885) it passes by this route into New York, but Marshall (1895) does not report it from the uppermost Allegheny and it has not been found in McKean County, Pennsylvania. From the Allegheny it enters French Creek and extends up to Cambridge Springs. It also enters Conneaut Outlet (but only one dead shell was found there). It is found in no other stream, and its absence is especially noticeable from the whole Beaver-drainage, where *L. ovata ventricosa* on the other hand is common.

No records from the Monongahela are known. However, it is probable that it once existed in the Monongahela proper, at least as far as to the West Virginia state line, for I was able to identify it among the shells from an Indian garbage heap at Point Marion (Ortmann, 1909*c*). It is not found in the upper Monongahela-drainage in West Virginia, where *L. ovata ventricosa* is locally abundant.

Thus *L. ovata* is clearly a form prefering larger rivers, and, according to my

observations, it inhabits in these the roughest parts, riffles with strong currents, the bottoms consisting of large stones, loosely piled over each other, with little finer material packing them together. Of course, occasionally it is found also in finer gravel. I have no doubt, that its chief characters are reactions to the conditions prevailing in riffles. The flattened or concave, truncate posterior slope is

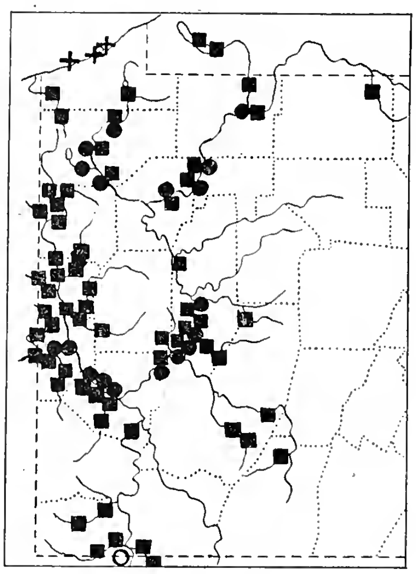

Fig. 32.

● *Lampsilis ovata.* ○ Indian garbage heap.
■ *Lampsilis ovata ventricosa.*
+ *Lampsilis ovata canadensis.*

produced by the current and the material rolled by it over the posterior end of the shell, when it is imbedded in the gravel; and the wedge-like attenuation of the anterior end is a device to enable the shell to plough through the heavy gravel in which it lives. I have seen the shell moving along in coarse gravel, and pushing aside stones, which were much larger than itself.

*General distribution: Type locality,* Ohio (Say).

It seems that the Ohio River, the Cumberland, and the Tennessee represent the metropolis of this species. Aside from western Pennsylvania, it is found in the Ohio proper in West Virginia (Carnegie Museum), Ohio (Sterki, 1907*a*), Indiana (Call, 1896*a* and 1900), and Illinois (Baker, 1906). It occurs in very few of the tributaries. Hildreth (1828) gives it from the Muskingum River at Marietta, Washington Co., Ohio; Sterki (1907*a*) from the Great Miami River; and Call from the Wabash, White, and Eel Rivers. In addition, I have found it in Elk River in West Virginia, but only as far up as Clay County. Above this point, its place is taken by *ventricosa,* and the mutual relations of these two forms are

exactly as elsewhere. In the Cumberland, it goes up to the falls (and a little beyond), according to Wilson & Clark (1914); and it has been reported from the Tennessee River as far up as the Holston (Lewis, 1871; Call, 1885), and here it reaches southwestern Virginia, as I have ascertained, in the Clinch River.

The distribution is thus rather restricted, being confined to the larger rivers of the Ohio system. Outside of Pennsylvania I found this species in the rough parts of rivers. In the Ohio below Pittsburgh, where there is more steady current and finer bottom material, it is by no means so abundant as in the Allegheny, for instance. The clam-diggers on the Ohio take it regularly, but not in great numbers.

I have treated as spurious a few records of this species from the lower St. Lawrence in Canada and the Maumee River.

### Lampsilis ovata ventricosa (Barnes) (1823).

*Lampsilis ventricosa* (Barnes) Simpson, 1914, p. 38.[198]

Plate XVIII, fig. 4; Plate XIX, figs. 1, 2, 3.

*Records from Pennsylvania:*

Harn, 1891 (western Pennsylvania) (as *U. occidens* and *U. subovatus*).
Stupakoff, 1894 (Allegheny Co.) (as *U. cariosus*).
Marshall, 1895 (Allegheny River, Warren Co.) (as *U. occidens*).
Rhoads, 1899 (specimens from Ohio River, Coraopolis, Allegheny Co., and from Beaver River, Wampum, Lawrence Co., recorded as *U. ovatus*, belong here).
Ortmann, 1909*b*, p. 182, 202.

*Characters of the shell:* Shell large, often very large, rather thin when young, but attaining considerable thickness when old. Outline subelliptical or subovate, rather short and high, hardly ever one-and-a-half times as long as high, mostly much shorter. Anterior margin rounded. Lower margin curved. Upper margin short, nearly straight, passing in a blunt angle or gentle curve into the obliquely descending posterior margin. Posterior and lower margins meeting in a blunt, rounded posterior point. Beaks more or less swollen, moderately elevated, located anterior to the middle of the shell. Beak-sculpture consisting of four or five rather coarse bars, of which the second and third have a slight tendency to fall into two loops, with a light sinus in the middle, while the first is indistinct, and the fourth

[198] According to Vanatta (1915, p. 551), *Lampsilis cardium* Rafinesque (1820) is this. I do not accept this identification, since the original description of Rafinesque clearly shows that *L. cardium* is the female of *L. ovata* (Say).

The figures of *Unio cariosus* given by DeKay (1843, Pl. 21, figs. 243, 244), quoted also by Simpson (1914, p. 44) under *L. cariosa*, are undoubtedly *L. ovata ventricosa*, and not *cariosa*.

and fifth tend to become obsolete. All the bars are effaced on the posterior slope. Valves more or less regularly convex, more flattened upon the sides. Posterior ridge poorly developed, mostly quite obsolete, and indicated only by a stronger convexity of the surface, but sometimes this ridge may become more distinct, chiefly so toward the beaks. Posterior slope gently convex or almost flat, but not concave.

Epidermis varying from lighter or darker yellowish green, to olive-brown; smooth and shining. Rays rarely absent, mostly present, but extremely variable. They are dark green to blackish, straight and continuous, finer or broader, and may cover the whole surface or only part of it. On the posterior slope the epidermis is less smooth, and generally darker. Concentric bands may be present.

Hinge well developed. Pseudocardinals generally two in each valve, but extremely variable in shape and size. In young specimens they are more or less compressed; in older ones, more stumpy and ragged. Interdentum absent or narrow. Laterals lamellar, high and strong, that of the right valve generally very broad and suddenly truncated posteriorly. Beak-cavity moderate. Dorsal muscle-scars in the beak-cavity. Adductor-scars distinct, rather well-impressed, chiefly so the anterior ones. Nacre silvery or bluish white, often with a pink blush, or more or less suffused with pink or purplish, but never entirely red.

Sexual differences of the shell well-marked. In the male, the lower margin is rather regularly curved, and the shell has a blunt posterior point. In the female the lower margin is considerably expanded in the postbasal region, the anterior portion thus becoming almost straight, while the posterior ascends suddenly to the blunt posterior end of the shell. The whole posterior section of the shell is much higher than in the male, more expanded, and broadly rounded.

| | | | L. | H. | D. |
|---|---|---|---|---|---|
| *Size:* | (Males) | 1. New Galilee, Cat. No. 61.2143 | 155 mm. | 120 mm. | 76 mm. |
| | | 2. Meadville, Cat. No. 61.3392 | 115 " | 74 " | 43 " |
| | | 3. Cannelton, Cat. No. 61.2881 | 76 " | 52 " | 32 " |
| | (Females) | 4. Neville Island, Cat. No. 61.1582 | 123 " | 88 " | 56 " |
| | | 5. New Galilee, Cat. No. 61.3236 (gravid) | 97 " | 71 " | 46 " |
| | | 6. Darlington, Cat. No. 61.2918 (gravid) | 89 " | 64 " | 40 " |

*Soft parts* (See Ortmann, 1912, p. 35) figured by Lea (Obs. VII, 1860, Pl. 30, fig. 107; Ortmann, 1911*b*, pp. 319, 320, figs. 7, 8). *Glochidia* (See Lea, Obs. VI, 1858, Pl. 5, fig. 13; Ortmann, 1911*b*, Pl. 89, fig. 23; Surber, 1912, Pl. 2, fig. 24). My measurements are: $0.25 \times 0.29$ mm.; while Surber gives: $0.205 \times 0.255$ mm. This is a rather unusual discrepancy.

*Breeding season:* I have a very complete series of dates for gravid females,

from July 30 to October 24, and from May 9 to July 8. The form is *bradytictic*, two succeeding breeding season approaching each other closely in July, but an interim is apparently present in this month. However, an occasional overlapping of the seasons is not impossible. Surber's notes (1912, p. 7) on the presence of glochidia are fragmentary, but they also indicate a possible overlapping of the seasons.

*Remarks:* The taxonomic relation of this form to *L. ovata* has been discussed above. Both are forms of the same species connected by numerous intergrades, but locally they may be pure. The true *ventricosa* is easily recognized by size, shape, and color. It differs from the allied *L. fasciola* in size, and in the character of the rays (not interrupted or wavy). From the eastern representatives, *L. cariosa* and *L. ochracea* it differs chiefly in size and color. *L. orbiculata* has a much heavier shell and different color.

*L. ovata ventricosa* is very variable in thickness, shape, and color. There is more or less tendency to form local races. In some creeks it attains giant proportions, while in others it has only a medium size. The latter is the case in the mountain-streams (Cheat, upper Loyalhanna, Quemahoning).

The typical characters, most of all the color, are best developed in shells of medium size. In the upper Ohio greenish is the prevailing tint of the epidermis, which is also glossy; though in old shells the epidermis frequently is discolored and loses its gloss, such shells appearing dull brownish or even blackish. On the average the greenish epidermis and the dark rays give to the shell a comparatively dark aspect, but specimens with light yellowish green or light brownish epidermis, and without rays, are not infrequent. If the nacre is strongly tinted with pink, this color sometimes influences the outer color in young specimens, which appear, reddish brown. A peculiar local race has developed in Lake Erie, and will be discussed below.

With regard to the convexity of the valves and the inflation of the beaks, the Pennsylvanian form varies a little, but not so much as in the southern and western sections of its range. In the South, it is represented by a form with much inflated beaks (*satura* Lea) which also often has a very dark blackish epidermis.

*Localities in Pennsylvania represented in the Carnegie Museum:*

*The Ohio and its smaller tributaries:*

Ohio River, Smith's Ferry, Cook's Ferry, Shippingport, and Industry, Beaver Co.; Coraopolis (S. N. Rhoads), Neville Island, and Edgeworth (G. H. Clapp), Allegheny Co.

Little Beaver Creek, Cannelton (Miss Vera White; H. H. Smith), Darlington, and New Galilee, Beaver Co.; Enon Valley, Lawrence Co.

Raccoon Creek, New Sheffield, Beaver Co.
Chartiers Creek, Carnegie, Allegheny Co. (D. A. Atkinson).

*Beaver-drainage:*

Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Connoquenessing Creek, Ellwood City, Lawrence Co. (G. H. Clapp & H. H. Smith); Harmony, Butler Co.
Slipperyrock Creek, Wurtemberg and Rose Point, Lawrence Co.
Mahoning River, Mahoningtown and Hillsville, Lawrence Co.
Neshannock Creek, Eastbrook, and Volant, Lawrence Co.; Leesburg, Mercer Co.
Shenango River, Harbor Bridge and Pulaski, Lawrence Co.; Clarksville, Shenango, and Jamestown, Mercer Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Little Shenango River, Greenville, Mercer Co.

*Allegheny-drainage:*

Allegheny River, Natrona, Allegheny Co.; Aladdin, Godfrey, Johnetta, Kelly, Mosgrove, Templeton, and Parkers Landing, Armstrong Co.; Walnut Bend, Venango Co.; Tionesta and Hickory, Forest Co.; Warren, Warren Co.; Larabee, McKean Co. (Dennis Dally).
Buffalo Creek, Harbison, Butler Co.
Conemaugh River, New Florence, Westmoreland Co.
Loyalhanna River, Idlepark and Ligonier, Westmoreland Co.
Quemahoning Creek, Stanton's Mill, Somerset Co.
Crooked Creek, Rosston and South Bend, Armstrong Co.
Little Mahoning Creek, Goodville, Indiana Co.
French Creek, Cochranton, Meadville, and Cambridge Springs, Crawford Co.
Leboeuf Creek, Waterford, Erie Co.
Connewango Creek, Russell, Warren Co.

*Monongahela-drainage:*

Monongahela River, Elizabeth, Allegheny Co. (D. A. Atkinson).
Tenmile Creek, Clarksville, Greene Co.
South Fork of Tenmile Creek, Waynesburg, Greene Co.
Dunkard Creek, Wiley and Mount Morris, Greene Co.
Cheat River, Cheat Haven, Fayette Co.

*Lake Erie-drainage:*

Conneaut Creek, West Springfield, Erie Co.; Springboro, Crawford Co.

*Other localities represented in the Carnegie Museum:*

*Lake-drainage:*

Genesee River, Rochester, Monroe Co., New York (R. H. Santens).
Chagrin River, Cuyahoga Co., Ohio (Hartman collection).
Sandusky River, Upper Sandusky, Wyandot Co., Ohio (C. Goodrich).
Maumee River, Roche de Boeuf Rapids, Lucas Co.; Defiance, Defiance Co., Ohio (C. Goodrich).
Beaver Creek, Williams Co., Ohio (C. Goodrich).
Raisin River, Adrian and Tecumseh, Lenawee Co., Michigan (C. Goodrich).

*Ohio-drainage:*

Lake Chautauqua, Chautauqua Co., New York (D. R. Sumstine; P. E. Nordgren; Miss B. Ortmann).

Tuscarawas River, Ohio (Holland collection).

Scioto River, Kenton, Hardin Co., Ohio (C. Goodrich).

West Fork White River, Riverside, Greene Co., Indiana (J. D. Haseman).

Wabash River, Bluffton, Wells Co., Indiana (C. Goodrich).

Ohio River, Toronto, Jefferson Co., Ohio; Portland, Meigs Co., Ohio.

Cheat River, Jaco and Mont Chateau, Monongalia Co., West Virginia.

West Fork River, Lynch Mines, Harrison Co.; West Milford, Harrison Co. (W. F. Graham); Lightburn and Weston, Lewis Co., West Virginia.

Little Kanawha River, Grantsville, Calhoun Co. (W. F. Graham); Burnsville, Braxton Co., West Virginia.

North Fork Hughes River, Cornwallis, Ritchie Co.; Harrisville, Ritchie Co. (W. F. Graham), West Virginia.

Pocatalico River, Raymond City, Putnam Co., West Virginia.

Elk River, Shelton and Clay, Clay Co.; Gassaway and Sutton, Braxton Co., West Virginia.

Little Coal River, Logan Co., West Virginia (Hartman collection).

Mud River, Milton, Cabell Co., WestVirginia.

Levisa Fork Big Sandy River, Prestonsburg, Floyd Co., Kentucky.

Licking River, Farmer, Rowan Co., Kentucky.

*Tennessee-drainage:*

Bear Creek, Burleson, Franklin Co., Alabama (H. H. Smith).

Shoals Creek, Lauderdale Co., Alabama (H. H. Smith).

Elk River, Fayetteville, Lincoln Co., and Estill Springs, Franklin Co., Tennessee (H. H. Smith).

Hurricane Creek, Gurley, Madison Co., Alabama (H. E. Wheeler).

Paint Rock River, Trenton, Jackson Co., Alabama (H. H. Smith).

Little River, Melrose, Blount Co., Tennessee.

Nolichucky River, Chunns Shoals, Hamblen Co., Tennessee.

Little Pigeon River, Sevierville, Sevier Co., Tennessee.

Holston River, McMillan and Mascot, Knox Co.; Hodges, Jefferson Co.; Turley Mill, Noeton, and Holston Station, Grainger Co.; Austin Mill, Hawkins Co., Tennessee.

South Fork Holston River, Pactolus, Bluff City, and Emmett, Sullivan Co., Tennessee.

North Fork Holston River, Rotherwood, Hawkins Co., Tennessee; Hilton, Scott Co., Virginia; Mendota, Washington Co., Virginia; Saltville, Smyth Co., Virginia.

Big Mocassin Creek, Mocassin Gap, Scott Co., Virginia.

Clinch River, Solway, Knox Co.; Edgemoor and Clinton, Anderson Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Speers Ferry and Clinchport, Scott Co., Virginia; St. Paul, Wise Co., Virginia; Fink and Cleveland, Russell Co., Virginia; Raven, Richland, and Cedar Bluff, Tazewell Co., Virginia.

Emory River, Harriman, Roane Co., Tennessee.

Powell River, Combs, Claiborne Co., Tennessee; Dryden, Lee Co., Virginia.

*Mississippi-drainage and westward:*

Mississippi River, Muscatine, Muscatine Co., Iowa (Hartman collection); Moline, Rock Island Co., Illinois (P. E. Nordgren).

James River, Galena, Stone Co., Missouri (A. A. Hinkley).

White River, Cotter and Norfolk, Baxter Co., Arkansas (A. A. Hinkley).

Black River (H. E. Wheeler), and Spring River (A. A. Hinkley), Black Rock, Lawrence Co., Arkansas.
Illinois River, Tahlequah, Cherokee Co., Oklahoma (F. B. Isely).
Fourteen Mile Creek, Fort Gibson, Muskogee Co., Oklahoma (F. B. Isely).

*Distribution and Ecology in Pennsylvania* (See fig. 32): This is a very common form in western Pennsylvania, and is practically found everywhere, both in large rivers and in small creeks. It is often associated with the typical *L. ovata*, in the large rivers, but is distinctly less abundant in these, and, as has been said, intergrades with *L. ovata*. In the smaller streams where typical *ovata* is missing it is extremely abundant, and becomes at favorable localities the prevailing species. It goes far up into the headwaters, eastward to McKean, Indiana, Westmoreland, and Somerset Counties. It should be noted, that it is also found in Conneaut Creek in the Lake Erie-drainage.

In its ecological preferences this form differs decidedly from the normal *L. ovata*, for it does not favor rough bottoms and currents, but rather quiet pools and eddies above and below riffles. Open pools in riffles, in *Dianthera*-patches, with moderate current, and a bottom of fine gravel covered with a thin layer of mud, seem to be most favorable habitats, and occasionally this form is found even in pure sand and rather deep and soft mud. It is the variety of smaller streams, where it is found in rather protected locations, while *L. ovata* is the variety of the rough waters of larger streams.

*General distribution: Type locality,* Wisconsin River (Barnes).

*L. ovata ventricosa* is found all over the Ohio and upper Mississippi drainages in western Pennsylvania, West Virginia, Ohio (Sterki, 1907*a*), Indiana (Call, 1896*a* & 1900), Illinois (Baker, 1906; Forbes & Richardson, 1913), Iowa (Pratt, 1876; Witter, 1878; Geiser, 1910), Wisconsin (Barnes, 1823; Cooper, 1855), and Minnesota (Cooper, 1855; Grant, 1886; Holzinger, 1888). It also largely crosses over into the lake-drainage in northern Illinois, Indiana, and Ohio, and occurs in Michigan (Walker, 1898). In New York, it is found in the upper Allegheny-drainage (Chautauqua Lake), and at many places in the St. Lawrence-drainage (Marshall, 1895). That the normal form is found here is shown by specimens from the Genesee River in the Carnegie Museum. In addition it has been reported from the lower St. Lawrence system and its lakes (Erie and Ontario); but in this region it is generally supplanted by the var. *canadensis* (See below), and since this has not been separated from *ventricosa* by most previous authors, the mutual geographical relation of these two forms is obscure. No localities from the Atlantic drainage in central New York are known, and it is missing on the Atlantic slope, with the exception of the upper Potomac River, where it has been introduced

artificially and accidentally in recent times (see Ortmann, Nautilus 26, 1912, p. 51, and 1913*a*, p. 318, and Marshall, Nautilus 31, 1917, p. 40). On the other hand, *L. ovata ventricosa* is reported to cross over, in the northwest, into the Red River and Nelson River systems in Canada, but little is known about the form of this region (See below, under *canadensis*).

In a southerly direction, records from Kentucky are scarce, and Wilson & Clark (1914) report it only from two tributaries of the Cumberland (Harpeth & Stones R.) in Tennessee. But it certainly is found in the upper Tennessee-drainage, where it has a similar relation to *L. ovata* as elsewhere, being preëminently found in smaller streams and in the headwaters.

Westward it goes through Missouri (Utterback, 1916) to southeastern Nebraska (Tryon, 1868; Call, 1885) and eastern Kansas (Scammon, 1906), and southwestward, it is found in Arkansas and Oklahoma. But in this region it passes into the southwestern race called *satura* Lea (Scammon, 1906). In the Alabama-drainage it is represented by allied forms, which require closer investigation.

Baker (1898) and Scammon (1906) say that it is generally found on muddy bottoms, and with some qualification this agrees with my observations in Pennsylvania.

### LAMPSILIS OVATA CANADENSIS (Lea) (1857).

*Lampsilis ventricosa canadensis* (LEA) WALKER, 1913, p. 21; *Lampsilis ventricosa lurida* SIMPSON, 1914, p. 41.

Plate XIX, figs. 4, 5.

*Records from Pennsylvania:*

Ortmann, 1909*b*, p. 202 (as the lake-form of *ventricosa*).

*Characters of the variety:* This form differs from *L. ovata ventricosa,* of which it is a local race, by its smaller size, and very light-colored epidermis, which is light-yellow, or light grayish or greenish yellow, with or without greenish rays. In some specimens, the color of the epidermis inclines toward reddish brown or chestnut, chiefly so near the beaks.

In other respects this form agrees with *L. ovata ventricosa,* but old specimens of the male sex are often more elongated than the average *ventricosa* (slightly over one-and-one-half times as long as high).

| | | L. | H. | D. |
|---|---|---|---|---|
| *Size:* (Males) | 1. Erie, Cat. No. 61.3989 | 101 mm. | 66 mm. | 46 mm. |
| | 2. do. " " 61.3982 | 93 " | 60 " | 42 " |
| | 3. do. " " 61.4883 | 68 " | 46 " | 33 " |
| (Females) | 4. Erie, Cat. No. 61.3982 (gravid) | 97 " | 68 " | 45 " |
| | 5. do. " " 61.4884 | 83 " | 63 " | 40 " |
| | 6. do. " " 61.4882 | 72 " | 54 " | 40 " |

*Soft parts* identical with those of *L. ovata* and *L. ovata ventricosa*. *Glochidia* not observed.

*Breeding season:* Gravid females have been seen only on May 21 and 22, 1909. Most of my specimens were collected in the month of July, and no gravid females were among them. Thus the interim seems to be in this month.

*Remarks:* Simpson (1914) calls this form var. *lurida* (of *ventricosa*), and believes that *U. canadensis* Lea is a synonym of *ventricosa*. However, I follow Walker (1913) in considering the lake-form to be *L. canadensis*.

This form has the same relation to *L. ovata ventricosa*, as has *L. luteola rosacea* to *L. luteola*. It is a small, stunted, light-colored lake-form, which under certain conditions shows the same tendency to become brownish near the beaks. The shell is very variable in color. Specimens from the surf-beaten beaches are very light in color, pale yellow; while those from protected locations in Presque Isle Bay are darker, and tend to have more or less chestnut color toward the beaks. The rays also vary greatly, and often are entirely absent.

Old shells frequently show a peculiar variation in shape, not found in *L. ovata ventricosa*, having a tendency to become more elongated. In this form the growth-rests are also often more regular and more distinct than in *ventricosa*, but this is not always the case. This character is best exhibited in specimens from deep water, and less so in specimens from the surf. The specimens from Ottawa River do not show this. They are also darker grayish green than the average specimens from Lake Erie.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Lake Erie, Presque Isle Bay, and outer beach of Presque Isle, Erie; beach at Miles Grove, Erie Co.

*Other localities represented in the Carnegie Museum:*

Ottawa River, Ontario, Canada (B. Walker, donor).

Lake Erie, Vermilion, (C. Goodrich), and Cedar Point, Erie Co., Ohio (C. Brookover; O. E. Jennings); La Plaisance Bay, Monroe Co., Michigan (C. Goodrich); Port Rowan and Port Dover, Norfolk Co., and Port Colborne, Welland Co., Ontario, Canada (C. Goodrich).

Lake Huron, Saginaw Bay, Charity Island, Michigan (C. Goodrich).

*Distribution and Ecology* (See fig. 32): *Type locality*, St. Lawrence River, Montreal, Canada (Lea).

Besides the St. Lawrence, this form is found in Ottawa River, and very likely at other localities in the lower St. Lawrence basin and Lake Ontario, generally credited to *L. ventricosa* (Marshall, 1895; Whiteaves, 1863; Bell, 1859). It is

common in Lake Erie (Walker, 1913), and is also in Lake Huron. Whether it extends farther west, remains to be seen.[199]

In the Lake Erie region *L. ovata canadensis* is restricted to the lake proper, and does not go into the tributaries. In the lake this form is found in protected bays as well as in the open lake, and it is one of the few species, which are found in the surf, where I repeatedly picked up living specimens thrown out by the waves. In Presque Isle Bay it is common everywhere, among rushes, and on open shores, going down to a depth of about fifteen feet. It is here mostly on sandy bottom. I never found it in the beach-pools.

### LAMPSILIS FASCIOLA Rafinesque (1820).

*Lampsilis multiradiata* (LEA) SIMPSON, 1914, p. 55.[200]

Plate XX, figs. 1, 2.

*Records from Pennsylvania:*

Harn, 1891 (western Pennsylvania).
Marshall, 1895 (Allegheny River, Warren Co.)
Rhoads, 1899 (Beaver River, Wampum, Lawrence Co.)
Ortmann, 1909*b*, p. 189.

*Characters of the shell:* The species is best described in terms of comparison with *L. ovata ventricosa*. It is much smaller, and relatively a little thicker. It has a more regularly ovate or elliptical outline. The posterior ridge is quite indistinct. But the chief difference is in the color-pattern of the epidermis. This is yellowish or greenish, or light brownish olive, with very numerous and crowded rays. The latter may be rather broad, or they may consist of bundles of fine (capillary) rays, and they are more or less wavy or interrupted. There are always many fine rays between the wider ones, and often only fine rays are present. The interrupted and wavy character is especially noticeable in the posterior part of the shell. Generally the rays are distinct, but sometimes they are indistinct in the anterior part of the shell. I have never seen a shell in which rays were entirely absent. According to my experience, the nacre is always white.

[199] I have two specimens (male and female) of a form of *ventricosa* from Sheyenne River, Argusville, Cass Co., North Dakota (S. M. Edwards), which represent a depauperate form, but differ from *L. canadensis* by the more elongated shape and the more compressed valves. The material is too insufficient to permit the expression of an opinion. *L. ventricosa* has been reported from the Red River of the North and from Nelson River, but little is known about these forms.

[200] According to Vanatta (1915, p. 552), *Lampsilis fasciola* of Rafinesque is *L. luteola* (Lamarck). Nevertheless in this case I do not accept the determination of the so-called (but *questionable*) "type," since Rafinesque's description is unmistakable, and refers to an ovate (not elongate) shell, with wavy, unequal rays. This fits only the present species.

The sexual differences agree with those of *L. ovata ventricosa.*

| | | | L. | H. | D. |
|---|---|---|---|---|---|
| *Size:* | (Males) | 1. Shenango, Cat. No. 61.4099 | 88 mm. | 58 mm. | 39 mm. |
| | | 2. do. " " do. | 62 " | 42 " | 29 " |
| | | 3. do. " " do. | 44 " | 29 " | 18 " |
| | (Females) | 4. Russell, Cat. No. 61.3433 (gravid) | 72 " | 53 " | 35 " |
| | | 5. New Galilee, Cat. No. 61.3240 (gravid) | 67 " | 51 " | 34 " |
| | | 6. Wurtemberg, Cat. No. 61.4890 (gravid) | 47 " | 36 " | 18 " |

The largest male listed above is the largest individual I have ever seen.

*Soft parts* (See Ortmann, 1912, p. 352). *Glochidia* (See Lea, Obs. VI, 1858, Pl. 5, fig. 17; Ortmann, *l. c.*; Surber, 1915, p. 1, Pl. 1, fig. 2). Surber gives the following dimensions: 0.230 × 0.290 mm.; while I gave: 0.25 × 0.29 mm.

*Breeding season:* The dates for gravid females are rather complete, extending from Aug. 4 to Oct. 23, and from May 14 to Aug. 9 (the last date furnished discharging specimens). Thus we would have the seasons overlapping early in August. The species is clearly bradytictic. (Discharge has been repeatedly observed in July.)

*Remarks:* This species is easily recognized and distinguished from *L. ovata ventricosa* by its small size, regular outline, and the character of the rays. I never

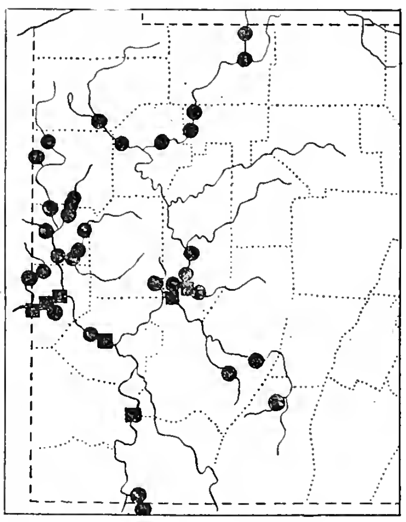

Fig. 33.

● *Lampsilis fasciola.*
■ *Lampsilis orbiculata.*

had any trouble in identifying it, and I have never seen any tendency to intergrade with *ventricosa*, and consider it a well-marked species.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Ohio River, Industry, Beaver Co.
Little Beaver Creek, Cannelton (H. H. Smith), Darlington, and New Galilee, Beaver Co.
Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).
Connoquenessing Creek, Ellwood City, Lawrence Co. (G. L. Simpson, Jr.).
Slipperyroek Creek, Wurtemberg and Rose Point, Lawrence Co.
Mahoning River, Mahoningtown, Lawrence Co.
Neshannock Creek, Eastbrook, and Volant, Lawrence Co.; Leesburg, Mercer Co.
Shenango River, Pulaski, Lawrence Co.; Shenango, Mercer Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Allegheny River, Aladdin, Godfrey, Johnetta, Kelly, and Templeton, Armstrong Co.; Walnut Bend, Venango Co.; Tionesta and Hickory, Forest Co.; Warren, Warren Co.
Buffalo Creek, Harbison, Butler Co.
Conemaugh River, New Florence, Westmoreland Co.
Loyalhanna River, Idlepark, Westmoreland Co.
Quemahoning Creek, Stanton Mill, Somerset Co.
Crooked Creek, Rosston, Armstrong Co.
French Creek, Utica, Venango Co.; Cochranton, Crawford Co.
Connewango Creek, Russell, Warren Co.
Cheat River, Cheat Haven, Fayette Co.

*Other localities represented in the Carnegie Museum:*

*Lake-drainage:*

Sandusky River, Upper Sandusky, Wyandot Co., Ohio (C. Goodrich).
Maumee River, Defiance, Defiance Co., Ohio (C. Goodrich).
Raisin River, Tecumseh, Lenawee Co., and Grape P. O., Monroe Co., Michigan (C. Goodrich).

*Ohio-drainage:*

White River, Rockford, Jackson Co., Indiana (G. H. Clapp, donor).
Cheat River, Jaco and Mont Chateau, Monongalia Co., West Virginia.
West Fork River, Lynch Mines, Harrison Co.; Lightburn and Weston, Lewis Co., West Virginia.
Little Kanawha River, Burnsvill, Braxton Co., West Virginia.
Elk River, Shelton, Clay Co.; Gassaway and Sutton, Braxton Co., West Virginia.
Coal River, Sproul, Kanawha Co., West Virginia.

*Tennessee-drainage:*

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).
Bear Creek, Burleson, Franklin Co., Alabama (H. H. Smith).
Shoals Creek, Lauderdale Co., Alabama (H. H. Smith).
Blue Water Creek, Lauderdale Co., Alabama (H. H. Smith).
Elk River, Estill Springs, Franklin Co., Tennessee (H. H. Smith).
Flint River, Maysville and Gurley, Madison Co., Alabama (H. H. Smith).
Hurricane Creek, Gurley, Madison Co., Alabama (H. E. Wheeler).
Paint Rock River, Paint Rock, Trenton, and Princeton, Jackson Co., Alabama (H. H. Smith).
South Chickamauga Creek, Ringgold, Catoosa Co., Georgia.
Little River, Melrose, Blount Co., Tennessee.

Little Pigeon River, Sevierville, Sevier Co., Tennessee.

Pigeon River, Canton, Haywood Co., North Carolina.

Holston River, McMillan and Mascot, Knox Co.; Turley Mill and Holston Station, Grainger Co., Tennessee.

South Fork Holston River, Pactolus, Bluff City, and Emmett, Sullivan Co., Tennessee; Barron, Washington Co., Virginia.

Watauga River, Watauga, Carter Co., Tennessee.

Middle Fork Holston River, Chilhowie, Smyth Co., Virginia.

North Fork Holston River, Rotherwood, Hawkins Co., Tennessee; Hilton, Scott Co., Virginia; Mendota, Washington Co., Virginia; Saltville, Smyth Co., Virginia.

Big Mocassin Creek, Mocassin Gap, Scott Co., Virginia.

Clinch River, Edgemoor and Clinton, Anderson Co.; Black Fox Ford, Union Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Clinchport, Scott Co., Virginia; St. Paul, Wise Co., Virginia; Fink and Cleveland, Russell Co., Virginia; Raven, Richland, and Cedar Bluff, Tazewell Co., Virginia.

Powell River, Combs, Claiborne Co., Tennessee; Dryden, Lee Co., Virginia.

*Distribution and Ecology in Pennsylvania* (See fig. 33): This species has about the same distribution in western Pennsylvania as *L. ovata ventricosa*, but it is missing in the Lake Erie-drainage. In the Ohio-drainage it is practically generally distributed, but is quite scarce, and never found in great numbers. In the Ohio below Pittsburgh I found it only once, and also in the Allegheny River in Armstrong County. Although found at a number of localities, it is rare. Farther up in the Allegheny and its tributaries it is met with regularly. It is possibly most abundant in Little Beaver Creek, and in the drainage of Beaver River. In the whole Monongahela-drainage it has been found only in the Cheat River, and more abundantly in West Virginia. It is to be noted that it goes up in the Conemaugh-drainage into the mountain-streams in Westmoreland and Somerset Counties.

In Pennsylvania it distinctly prefers riffles with lively currents and gravelly bottoms, but it is not found in very strong currents and among large rocks. The most favorable localities seem to be riffles with an abundant growth of *Dianthera americana* and other water weeds. It distinctly differs in its ecology from *L. ovata ventricosa*, although often found in close proximity to it. But while the latter prefers more quiet water above and below the riffles, *L. fasciola* is found *in* the riffles.

*General distribution: Type locality*, Kentucky River (Rafinesque).

According to Simpson (1900) it is found in the entire Ohio-drainage; in southern Michigan and in New York. This is essentially correct. In the Ohio-drainage it is practically everywhere, in western Pennsylvania, West Virginia, in Ohio (Sterki, 1907*a*), and Indiana (Call, 1896*a*, 1900). In Illinois it seems to be

less widely distributed, but has been reported from the southern as well as the northern parts of the state (Baker, 1906). Records from Kentucky are scarce (type locality and Green River, according to Call, 1885). In the Cumberland it is rare in the main river, but common in the tributaries (Wilson & Clark, 1914). In the Tennessee-drainage it seems to be abundant, from Tennessee and Alabama up to the affluents in Virginia, being found in this region chiefly in the smaller streams. In this region it has also been reported (by Call, 1885) from the French Broad River in North Carolina, and I found it in the Pigeon River in North Carolina.

South of the Tennessee and West of the Mississippi it is absent.

In addition it has crossed over into the lake-drainage in Indiana, St. Joseph River, Michigan basin, and Maumee River (Call, 1896*a*) and Ohio (Sterki, 1907*a*), and is found in the latter state and in southeastern Michigan in the drainage of Lake Erie (Walker, 1898).[201] It is not known to go up in the Allegheny-drainage into New York state, but Marshall (1895) gives it from Medina, Orleans Co., and the Genesee River, Monroe County, in the Lake Ontario-drainage, and from Butternut Creek in Otsego County (tributary to the Susquehanna). These localities should be confirmed, and Simpson treats them as doubtful.

Baker (1898*a*) says that, like *Eurynia iris*, this species is found in lakes and rivers on a sandy or muddy bottom. This is not at all confirmed by my observations in Pennsylvania. In the upper Tennessee-drainage, where the species is abundant, it prefers rather rough parts of the streams, and ascends (in French Broad and Pigeon Rivers) into the high Appalachians in North Carolina.

### LAMPSILIS CARIOSA (Say) (1817).[202]

*Lampsilis cariosa* (SAY) SIMPSON), 1914, p. 43.[203]

Plate XX, figs. 3, 4, 5.

*Records from Pennsylvania:*

Say, 1817 (Delaware and Schuylkill Rivers, Philadelphia).
Haldeman, 1844 (Lancaster Co.).

[201] Maumee River (Dall & Simpson, 1895) and Cuyahoga River (Dean, 1890) in Ohio, and Huron and Detroit Rivers, in Michigan (Walker, 1892, see also material in Carnegie Museum); also reported from Lake Erie proper by Walker, 1913, but never found on the Pennsylvanian shores.

[202] Not 1816.

[203] The figures of Conrad (Mon. 4, 1836, Pl. 19) are fine representations of this species, and the same is true of his figures of *U. ochraceus* (Pl. 17, fig. 2). If subsequent authors had paid due attention to these figures, the prevailing confusion of these two species (and of the related western forms) would have been impossible. DeKay s figures (1843, Pl. 21, figs. 243, 244) surely do not represent *cariosus*, but are *L. ovata ventricosa*. Simpson (1895) on pp. 121 and 122 also figures *cariosus* and *ochraceus*, and

Gabb, 1861 (Delaware River, Tacony, Philadelphia Co., and Bristol, Bucks Co.)
Bruckhart, 1869 (Lancaster Co.)
Hartman & Michener, 1874 (Schuylkill, Delaware, and Susquehanna Rivers).
Pilsbry, 1894 (York Furnace, York Co.)
Schick, 1895 (Delaware River, Philadelphia).
Ortmann, 1909*b*, p. 204.
Caffrey, 1911, reports *U. ochraceus* from the Delaware in Northampton County, but there is no question that under this name he designates *U. cariosus*.

*Characters of the shell:* Of medium size, rather thin when young, but becoming thicker when old. Outline ovate or subelliptical, rather short and high, but old males are often somewhat elongated, and may be slightly over one-and-a-half times as long as high; but generally the length is less than this. Anterior margin rounded. Lower margin more or less curved. Upper margin short, straight or a little convex, passing into a blunt angle or gradually into the obliquely descending posterior margin. Posterior end a rounded, blunt angle. Beaks moderately swollen, not much elevated, anterior to the middle of the shell. Beak-sculpture (Marshall, 1890, fig. 8) consisting of about five not very distinct bars, the first subconcentric, the following ones slightly double-looped, with a light sinus in the middle, obsolete in the last bars. Upon the posterior slope, the bars are effaced. Valves regularly convex, somewhat flattened upon the sides. Posterior ridge very indistinct, practically absent. Posterior slope gently convex, or almost flat.

Epidermis yellow, very smooth and shining. The yellow is wax- or straw-yellow, with hardly a trace of green in it, but sometimes inclining to brown or reddish brown. Rays either entirely absent, or present upon the posterior slope and a little in front of it. They are variable in width, but are generally fine, straight, and sharply defined, dark green or blackish in color, contrasting strongly with the light epidermis. Concentric bands of light or dark color absent or indistinct. In old specimens the color of the epidermis is less bright, and becomes dirty grayish or brownish yellow.

Hinge well-developed. Pseudocardinals generally two in each valve, quite variable in shape. In young specimens they are rather compressed, in older ones more stumpy and ragged. Interdentum practically absent. Laterals lamellar, generally somewhat elevated and truncate at their posterior ends. Beak-cavity moderate. Dorsal muscle-scars in the beak-cavity. Anterior adductor-scars distinct and impressed, posterior ones less distinct. Nacre silvery white, often suffused with cream- or salmon-color, but not reddish.

later (1900, p. 529, footnote 1, and p. 530, footnote 2) says, that the two figures had been accidentally transposed. But these figures are copies from Hartman & Michener (1874, figs. 183, 184) where the same mistake is made. I think, both of these figures represent *cariosus*, and the one named *ochraceus* is certainly the female of *cariosus*.

Sexual differences of shell strongly marked. In the male, the lower margin is more regularly convex, joining the posterior margin in a blunt posterior point, and the outline of the shell is more regularly elliptical. In the female, the lower margin is considerably expanded in the posterior region, sloping up very strongly to the blunt posterior end, so that the posterior part of the shell is higher and more broadly rounded.

| | | L. | H. | D. |
|---|---|---|---|---|
| *Size:* (Males) | 1. Selinsgrove, Cat. No. 61.4894 | 122 mm. | 80 mm. | 51 mm. |
| | 2. Duncannon, Cat. No. 61.3416 | 113 " | 74 " | 41 " |
| | 3. Yardley, Cat. No. 61.3417 | 80 " | 50 " | 32 " |
| (Females) | 4. York Haven, Cat. No. 61.4893 | 96 " | 71 " | 44 " |
| | 5. South Waverly, Cat. No. 61.4003 (gravid) | 91 " | 67 " | 46 " |
| | 6. Yardley, Cat. No. 61.3417 (gravid) | 70 " | 52 " | 36 " |

*Soft parts* (See Ortmann, 1912, p. 352). *Glochidia, ibid.* (the latter not fully known, only immature individuals having been observed).

*Breeding season:* Gravid females were observed on the following dates: Aug. 13, 1908; Aug. 14, 1908; Aug. 14, 1910; Aug. 20, 1909; Aug. 22, 1909; Aug. 24, 1908. Only on the last date were glochidia (immature) found; all other specimens had only eggs. But just these meagre facts establish the beginning of the breeding season in August, and very probably this species agrees with the allied forms, and is *bradytictic,* discharging the glochidia in the subsequent spring or early summer.

*Remarks:* An exceedingly well defined species, easily recognized. Nevertheless great confusion prevails with regard to it. This confusion is principally due to the fact that De Kay (1843) misunderstood this and some allied species, and that the two sexes of *cariosus* were regarded as different species by other authors (Gould-Binney, and Hartman & Michener). Simpson (1895) tried to straighten out the confusion, but unfortunately copied two old erroneous figures, and committed an additional error, and thus it has happened that even some recent authors (Conner, 1909, and Caffrey, 1911) confused this species with *L. ochracea.*

*L. cariosa* is allied to the western *L. ovata ventricosa,* but is smaller than the latter, in the male sex is more regularly elliptical, has hardly a trace of a posterior ridge, and is entirely and characteristically different in color and color-markings. The bright and light yellow of the epidermis and its high gloss are entirely different from the greenish-olive tints of *L. ovata ventricosa,* and the restriction of the rays (if such are present) to the posterior section of the shell is also characteristic. Of course, these characters are best seen in young or medium-sized individuals, while in older specimens the smoothness disappears, and the color becomes more dirty: nevertheless even in very old shells the light yellow is generally present at least on

certain parts of the shell. This color is so eminently characteristic, that even laymen have noticed it, and people living on the banks of the Susquehanna and Delaware properly distinguish this species as the "yellow clam."

The variation of this species occurs chiefly in the external shape (more or less elongate) and the development of the rays. Moreover the yellow of the ground-color varies slightly, being lighter or more intense, often inclining toward reddish brown in parts of the shell.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Delaware River, Taylorsville (C. H. Conner) and Yardley, Bucks Co.; Shawnee, Monroe Co.[204]

Susquehanna River, York Furnace and York Haven, York Co.; Duncannon, Perry Co.; Selinsgrove, Snyder Co.

Conewago Creek, York Haven, York Co. [205]

Juniata River, Juniata Bridge, Perry Co.; Lewistown, Mifflin Co.

Frankstown Branch, Juniata River, Huntingdon, Huntingdon Co. (D. A. Atkinson).

Raystown Branch, Juniata River, Ardenheim, Huntingdon Co.

West Branch Susquehanna River, Williamsport, Lycoming Co. (D. A. Atkinson).

North Branch Susquehanna River, Tunkhannock, Wyoming Co.

Chemung River, South Waverly, Bradford Co.

*Other localities represented in the Carnegie Museum:*

Connecticut River (Hartman collection).

Delaware River, Newbold, Gloucester Co., New Jersey (C. H. Conner).

Potomac River, Cabin John, Montgomery Co., Maryland (J. D. Haseman); Mount Vernon, Fairfax Co., Virginia (Juny collection).

Savannah River (Hartman collection).[206]

*Distribution and Ecology in Pennsylvania* (See fig. 31): This species belongs to the Delaware and Susquehanna drainages in Pennsylvania, but has not been found in the small tributaries of the Potomac in our state. In the Delaware River it goes up to above the Delaware Water Gap, but its scarcity just above the gap indicates, that at this point it approaches the upper limit of its range. In the Susquehanna it is practically everywhere, ascending at least to Williamsport, Lycoming Co., in the West branch, and to the New York state line in the North

[204] Shawnee is immediately above the Delaware Water Gap: only one specimen was found here and no dead shells were lying around.

[205] In the lowermost part only of this creek, where there is at times water from the Susquehanna.

[206] A large, thick-shelled specimen, labeled *rosaceus* Conrad, agrees well with Conrad's description, but is larger, and has only a faint blush of pink on the nacre. In other respects it agrees likewise with *cariosus*, and, although discolored, the epidermis shows remnants of the gloss. If locality and identification are correct, *rosaceus* is a form of *cariosus*, not of *ochraceus* (of which Simpson makes it a synonym). Whether this form is different from *cariosus* (as variety or species) cannot be decided from a single individual.

branch. It is generally restricted to the main river, and only enters some of the larger tributaries, for instance the Schuylkill, Juniata, and Chemung Rivers. In the smaller tributaries it is absent, and the only specimen found by myself in Conewago Creek, was in its lowermost part, which, during high water forms a branch of the Susquehanna.

Where found this species is generally abundant, even in smaller streams like the Juniata in Huntingdon County, where it reaches its farthest advance in the mountains. It is always found in lively currents, on shoals and riffles, in finer or coarser gravel, and very often in bars of pure sand. Although it has been reported from the tidewater region of the lower Delaware, it does not seem to be abundant there (I did not find it near Fish House, Camden Co., New Jersey).

In Pennsylvania its metropolis is apparently the Delaware from Trenton upward, and the Susquehanna from the region of York Haven to the point where the West and North branches unite.

*General distribution: Type locality,* Delaware River, Philadelphia (Say).

According to Simpson (1900) this species is found in the "Atlantic-drainage from Georgia to the lower St. Lawrence," but this possibly requires some restriction. Its occurrence in the lower St. Lawrence is extremely questionable, and rests chiefly upon the statement of Marshall (1895), who also gives it from Maine (confirmed by Lermond, 1909, and Johnson, 1915). It is undoubtedly found in Massachusetts and Connecticut (Gould-Binney, 1870, Marshall, 1895, Linsley, 1848, Johnson, 1915). From New York it has been reported (Marshall, 1895) from the Hudson-drainage up to, and even above, Albany, and there seems to be even a western extension of the range through the Erie canal to Onondago and Ontario Counties, but this should be investigated again, since it is not quite sure that Marshall understood this species correctly. De Kay (1843) reports it from the Passaic River, Belleville, Essex Co., New Jersey, and the species should exist there: however, De Kay's figures represent, as has been said, *L. ovata ventricosa.* Marshall (1895) gives it from the Raritan River, Somerville, Somerset Co., New Jersey. Its distribution in Pennsylvania has been discussed above. From Delaware it is known from Seaford, Sussex Co. (Rhoads, 1904). From the Potomac River it has been reported from the District of Columbia and from the canal at Alexandria, Fairfax Co., Virginia (Marshall, 1895), and it is found in Maryland above Washington. However, it does not ascend far up in this river, and is surely absent in the whole Potomac-drainage West of the Blue Ridge.

To the South of the Potomac, records become very scarce. Conrad (1836) says that it is rare in the Potomac as well as in the James River, and since Conrad

correctly understood the species, we must accept this latter locality. "Georgia," given by Simpson, probably rests upon Conrad's record of *U. oratus* from Flint River, and if *U. rosaceus* Conrad should actually belong here, we would also have to include the Savannah River. However these southern localities emphatically need confirmation in view of the fact that from the James River southward, in Virginia and the Carolinas, not a single reliable record is at hand.

As to the standing of this species in the Atlantic fauna, see Ortmann, 1913*a*, pp. 325 & 363.

### LAMPSILIS OCHRACEA (Say) (1817).[207]

*L. ochracea* SIMPSON, 1914, p. 49.[208]

Plate XX, figs. 6, 7.

*Records from Pennsylvania:*

Say, 1817 (Delaware and Schuylkill Rivers, " with the preceding," namely *U. cariosus*).
Conrad, 1836 (Delaware and Schuylkill Rivers).
Gabb, 1861 (Schuylkill and Wissahickon, Philadelphia; League Island, Philadelphia).
Schick, 1895 (Delaware River, Philadelphia).
Marshall, 1895 (Philadelphia).

Hartman & Michener have confounded this species with *L. cariosa*, and their records: Schuylkill, Delaware, and Susquehanna are unreliable. This species has never been found in the Susquehanna in Pennsylvania. Caffrey (1911) records it from the Delaware, Northampton Co., but he certainly refers to *L. cariosa*. See also Ortmann (1909*b*, pp. 204 & 209).

*Characters of the shell:* Having only scanty material at hand, I confine myself to giving only the characters of this species differentiating it from its allies, chiefly *L. cariosa*.

*L. ochracea* is a rather small, thin shell, much thinner than *L. cariosa*, and much thinner and smaller than any of its western relations (*ventricosa*, *fasciola*). It resembles these in outline, but is mostly somewhat shorter than *L. cariosa*, and has a slightly more distinct posterior ridge. The chief difference is in the epidermis, which does not have the gloss of *L. cariosa*, and becomes quite rough toward and on the posterior slope. The color is dull, not bright yellow, but grayish, greenish, yellowish, or brownish olive, a grayish green being the prevailing hue; and the rays have a different character. Sometimes the latter are entirely absent, but (when present) they are not sharp and blackish, but indistinct, and grayish or grayish green, rather fine, and cover all or a large portion of the surface. Upon the posterior slope, the rays are obscure, and sometimes somewhat wider.

[207] Not 1816.

[208] The figures of DeKay (1843, Pl. 19) do not represent this species, but *L. radiata* (See above, p. 292, footnote 191). Very probably the figure of Gould-Binney (1870, p. 174, fig. 476), and certainly that of Hartman & Michener (1874, p. 89, fig. 184) represent females of *L. cariosa*. There is only one good figure of this species, that of Conrad (Mon. 4, 1836, Pl. 17, fig. 2) which represents the male.

The nacre in all my specimens is silvery white, but is said to be sometimes more or less reddish. Corresponding to the thinness of the shell, the hinge-teeth are delicate, thin, and compressed. The sexual differences of the shell are similar to those of *L. cariosa*. Beak-sculpture as described by Marshall (1890, fig. 7), and resembling that of *L. cariosa*, but the median sinus of the bars is very indistinct or even missing. I have only a single individual which shows the beak-sculpture.

| | L. | H. | D. |
|---|---|---|---|
| *Size:* 1. Newbold, Cat. No. 61.4012 (♂) | 62 mm. | 42 mm. | 26 mm. |
| 2. do. " " do. (♀) | 46 " | 30 " | 20 " |
| 3. Plymouth, Cat. No. 61.667 (♀) | 38 " | 29 " | 18 " |
| 4. Princeton, Cat. No. 61.1571 (sex ?) | 32 " | 22 " | 13 " |

This species grows somewhat larger, but the largest male given above is about the average size.

*Soft parts* and *glochidia* practically unknown. Lea (Obs. II, 1838, Pl. 15, fig. 44) has given a poor figure of the soft parts of a gravid female, and an incomplete description (Obs. X, 1863, p. 455).

*Breeding season:* Through Lea (Obs. II, 1838, p. 54) we know that this species is gravid in autumn (October, November). Lea also reports (*l. c.*, p. 57) a female charged with eggs for June 5. Conner (1909) has confounded this species with *L. cariosa*, and thus we cannot depend on his dates.

*Remarks:* This species has been often misunderstood and confounded with *L. cariosa*. In general terms it may be defined as a rather small and thin shell, with dull-colored epidermis, and fine, indistinct, or missing rays, which, when present, cover a larger part of the shell than is the case in *L. cariosa*.

*Localities represented in the Carnegie Museum:*

Plymouth, Plymouth Co., Massachusetts (Hartman collection).
Delaware-Raritan Canal, Princeton, Mercer Co., New Jersey.
Delaware River, Newbold, Gloucester Co., New Jersey (C. H. Conner) (received as *L. cariosa*).
Lake Wacamaw, Columbus Co., North Carolina (G. H. Clapp, donor).

*Localities represented in the Philadelphia Academy.*

Ditches of Delaware Meadows, League Island, Philadelphia, Pa.
Delaware River, Westville, Gloucester Co., New Jersey (Morris Schick).
Delaware River, Kaighns Point, Camden, Camden Co., New Jersey (John Ford).

*Distribution and Ecology* (See fig. 31): *Type locality,* Delaware River, Philadelphia (Say).

According to Simpson (1900) this species is in the "Atlantic-drainage, from New England to the Ogeechee River, Georgia," that is to say, it occupies about

the same range, as that given by him for *L. cariosa*. But, as we have seen, in the south *L. cariosa* is doubtful.

The species has been reported from Maine (Marshall, 1895; Lermond, 1909), from Massachusetts (Earle, 1835; Gould-Binney, 1870; Marshall, 1895), from Connecticut (Linsley, 1845) (See also New England localities given by Johnson, 1915). It is known from the Hudson in New York, and is said to go up here to Albany and the Mohawk River, Herkimer Co. (Marshall). In Pennsylvania, it is restricted to the lower Delaware, and the lowlands near to it. It has been found in the lower Schuylkill and also Wissahickon Creek. According to specimens I have seen in the Philadelphia Academy, it is abundant in the ditches of the meadows near League Island. It is unknown from the Susquehanna and Potomac drainages in Pennsylvania, although known from the lower Potomac in the District of Columbia (Marshall), Prince George Co., Maryland (Lea, Obs. X, 1863, p. 456), and Fairfax Co., Virginia (Marshall). Rhoads (1904) reports it from Seaford, Sussex Co., Delaware, and farther south it is abundant in the lower James River, Virginia (Conrad, 1836) and according to the same author in "most tide-waters north of the Savannah River." The most southern record is that of Simpson from the Ogeechee River in Georgia.

In Pennsylvania, *L. ochracea* is decidedly rare, and restricted to the tide-waters of the Delaware. It is not at all coëxtensive with *L. cariosa,* since the latter ascends the rivers for a considerable distance. The same seems to be true in other parts. Most of the exact localities known are in the tidewater-regions of the Atlantic streams, and Conrad calls especial attention to this. Thus the ecological preferences of this species seem to be for the estuaries of our large rivers. In the Hudson it goes up quite far, but in the vicinity of Albany it has been reported chiefly from canals, and it seems that it also frequently inhabits canals and ponds. I found it myself in the Delaware-Raritan Canal in New Jersey. Thus the species differs ecologically from *L. cariosa*. It is a form of estuaries, ponds, canals, and ditches, probably with more or less muddy bottoms, while *L. cariosa* favors large rivers, with sandy and gravelly bottoms and strong currents. A closer study of these conditions is very desirable (See Ortmann, 1913*a*, pp. 325, 368).

### Lampsilis orbiculata (Hildreth) (1828).

*Lampsilis orbiculata* (Hildreth) Simpson, 1914, p. 76.

Plate XX, fig. 8; Plate XXI, figs. 1, 2.

*Records from Pennsylvania:*

Clapp, 1895 (Allegheny Co.)
Ortmann, 1909*b*, p. 190.

*Characters of the shell:* Of medium size to rather large (but not as large as *L. ovata*), extremely thick and heavy (one of the heaviest shells for its size). Outline subelliptical or subovate, very variable and often irregular, chiefly so in the female, always less than one-and-a-half times as long as high. Anterior margin rounded. Lower margin convex, sometimes rather uniformly so, but in other cases the middle part of the lower margin is less convex, and the posterior part slopes up rather steeply. Upper margin short, gently convex, passing gradually into the obliquely descending posterior margin, without forming a distinct angle. Posterior and lower margins uniting posteriorly in a blunt angle, which may be obliterated. Beaks moderately swollen, and little projecting above the hinge-line, more or less inclined forwards, and located in front of the middle of the shell. Beak-sculpture obsolete. Although I possess specimens with fairly well preserved beaks, I cannot see any distinct beak-sculpture. Valves more or less convex, generally moderately so, but old specimens, chiefly females, are much more convex (almost globular). The convexity is least upon the sides, greatest in the region of the posterior ridge. The latter, however, is quite indistinct. Posterior slope slightly convex or flattened, narrow.

Epidermis brown, light or dark yellowish brown or reddish brown, generally without any trace of green shades. This color is rather uniform, and no concentric bands of light and dark are present. Rays either absent (chiefly in older shells), or, when present, faint and indistinct. In young, well-preserved specimens, the rays are fine or moderately wide, but not dark (black or dark green), but gray or grayish green, or brownish. They are not sharply contrasted with the ground-color, and disappear toward the lower margin, so that older shells have rays only near the beaks. In very old specimens the general color becomes uniformly dirty brown, but not very dark brown.

Hinge well developed. Pseudocardinals two in left, one or two in right valve (the anterior one smaller), variable in shape, strong, stumpy and ragged. Interdentum narrow. Laterals moderately long, slightly curved, thick and heavy. Beak-cavity moderate. Dorsal muscle-scars in the beak-cavity. Adductor-scars distinct, all deeply impressed, the posterior scars less so. Nacre silvery white, very often with more or less pink, chiefly in the beak-cavity and near the hinge, and sometimes the whole interior of the shell is suffused with beautiful salmon or pink. But in other cases the pink shades may be entirely absent.

Sexual differences of the shell very strongly marked. In the male the outline is rather regularly subovate or subelliptical, with the lower margin rather regularly curved, meeting the posterior margin in a blunt point. In older males

the lower margin may be almost straight in the middle, and the posterior end may be rounded off. In the female the lower margin projects in the postbasal region, so that the anterior and middle part is almost straight, and the posterior part ascends very suddenly, forming with the part in front a more or less distinct rounded angle, and joining the posterior margin in a very blunt angle. Thus the posterior part of the female shell becomes very high, and in old females this may go to such an extreme that the height of the shell nearly equals the length, thus rendering the outline almost orbicular. In some cases such old females are also much more convex, so that the whole shell approaches the globular shape.

| | | | L. | H. | D. |
|---|---|---|---|---|---|
| *Size:* | (Males) | 1. Portsmouth, Cat. No. 61.4898 | 103 mm. | 75 mm. | 61 mm. |
| | | 2. Neville Island, Cat. No. 61.2046 | 100 " | 76 " | 57 " |
| | | 3. Kelly, Cat. No. 61.3017 | 80 " | 59 " | 36 " |
| | (Females) | 4. Industry, Cat. No. 61.3500 (gravid) | 92 " | 83 " | 57 " |
| | | 5. do. " " do. | 89 " | 70 " | 49 " |
| | | 6. Godfrey, Cat. No. 61.3504 | 74 " | 57 " | 34 " |

The largest specimen I have seen is from the Clinch River, at Offut, Anderson Co., Tennessee, and measures: L. 104, H. 82, D. 53 mm. It has the shape of the female.

*Soft parts* (See Ortmann, 1912, p. 353). *Glochidia* (See Ortmann, 1911*b*, Pl. 89, fig. 22).

*Breeding season:* The following records for gravid females are at hand. Aug. 10, 1909; Aug. 24, 1910; Aug. 29, 1908; Sept. 8, 1908; Sept. 10, 1908; Sept. 12, 1914; Sept. 17, 1908; Sept. 23, 1908. Sept. 8 is the earliest date for glochidia. A female just discharged was collected in Ouachita River by Mr. Wheeler on June 26, 1911.

This is apparently a *bradytictic* form, beginning to breed in August, having glochidia in September, which are discharged the next spring (June).

*Remarks:* This species, when well-developed, is easily recognized by the extremely heavy shell, by the brown color with indistinct rays, and the general presence of a delicate pink color in the nacre. However, it is very variable with regard to shape. The males, and chiefly the young males, very much resemble *Actinonaias ligamentina,* so much so in fact, that this species has been placed by the side of *L. ligamentina* in Simpson's system. Yet there is no close relationship between the two species. Young males of *L. orbiculata* differ from *A. ligamentina* by the brown color of the epidermis, and the indistinct and finer rays: however, sometimes the latter species also has a brownish epidermis, and in such cases it is hard to separate them.

The female of *L. orbiculata* is entirely different from that of *A. ligamentina* in shape. The posterior dilatation is not found in *A. ligamentina,* and the latter never approaches the globular shape.

Both male and female of *L. orbiculata* often present freakish shapes, and the proportion of length and height, convexity of the valves, and curvature of the lower margin is hardly alike in any two specimens.

A very good character, excepting in the case of very young shells, is always the thickness of the shell. In fact for its size this species is possibly the heaviest shell of the Ohio-drainage.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Ohio River, Shippingport, Cooks Ferry, and Industry, Beaver Co.; Neville Island, Allegheny Co.
Allegheny River, Godfrey and Kelly, Armstrong Co.
Monongahela River, Charleroi, Washington Co. (G. A. Ehrmann).

*Other localities represented in the Carnegie Museum:*

Ohio River, Toronto, Jefferson Co., Ohio; St. Marys, Pleasants Co., West Virginia; Portland, Meigs Co., Ohio; Portsmouth, Scioto Co., Ohio.
Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).
Clinch River, Solway, Knox Co., and Offutt, Anderson Co., Tennessee.
Mississippi River, Muscatine, Muscatine Co., Iowa (Hartman collection); Andalusia, Rock Island Co., Illinois (A. D. Howard).
Black River, Black Rock, Lawrence Co., Arkansas (H. E. Wheeler); Pocahontas, Randolph Co., Arkansas (H. E. Wheeler).
Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler).[208a]

*Distribution and Ecology in Pennsylvania* (See fig. 33): This is a rare shell in Pennsylvania, and is only found in the larger rivers. The largest number of specimens has been secured in the Ohio in Beaver County, but here also it is by no means abundant. It used to be in the Ohio in Allegheny County, and in the Monongahela as far up as Charleroi, Washington Co. (only one individual is at hand from this locality). It also ascends the Allegheny to Armstrong County, but here it is extremely rare, and only a few specimens were taken.

So far as I am able to judge, it is a shell of strong currents in large rivers. I found all my specimens on riffles; but farther down in the Ohio it is present upon

[208a] See Wheeler (1918, p. 117). Specimens from the Ouachita River agree very well in shape with specimens from the Ohio River and the color of the epidermis is of the same brown hue in some of them, but in others it is more brownish-olive (with a suggestion of green). They are surely not *L. higginsi,* because the beaks are not at all inflated. The form from Black River is remarkable on account of its rays, which are broad and distinct; and also by the brownish-olive epidermis. It belongs to the forms intergrading with *L. higginsi* (Lea).

the shell-banks, among other bed-forming species. But here also it is not very frequent, and the shell-heaps of the clam-diggers contain only small numbers. These conditions remain the same all the way down to Portsmouth. Every specimen found by myself has been taken, but the total sum collected from the Ohio below Pennsylvania hardly amounts to two dozen.

*General distribution: Type locality,* Muskingum River, Marietta, Washington Co., Ohio (Hildreth).

This species is found extending from western Pennsylvania down the Ohio in the states of West Virginia, Ohio (Sterki, 1907*a*), Indiana (Call, 1896*a*), and probably also Illinois and Kentucky. In the upper parts of the Ohio-drainage it hardly goes into the tributaries. The type locality, Muskingum River, has remained so far the only tributary, which contains it in Ohio. In Indiana it is also found in the Wabash and White Rivers (Say, 1817, Call, 1896*a* and 1900), and in Illinois (Baker, 1906) it is in the Wabash and in the Illinois River (as far up as La Salle Co.). It is in the Mississippi River in Illinois as well as in Iowa (Davenport, Scott Co.) according to Pratt (1876). Simpson (1900) says that it ascends the Mississippi to Minnesota, but it has not been reported by Grant (1886) and Holzinger (1888), and is not reported from Wisconsin by Lapham (1860).

From the southern tributaries of the Ohio it is known from the Cumberland River (Call, 1885; Simpson, 1900; Wilson & Clark, 1914) and in the Tennessee, it goes up to the Clinch River in Anderson Co., Tennessee.

West of the Mississippi previous records are scarce or doubtful. While Call (1885) gives this species from Blue River in Kansas, Scammon (1906) records *L. higginsi* for this river. The latter species, according to Simpson, is found from the (probably lower) Ohio west to Iowa and southwest to Kansas.[209] However, specimens sent to me by H. E. Wheeler from Ouachita River in Arkansas are undoubtedly *L. orbiculata,* and thus the latter certainly goes southward to the Ouachita River. Specimens from Black River, however, distinctly incline toward *higginsi.* Utterback (1916) has only *higginsi* from Missouri, but not *orbiculata.*

It is quite possible that *L. higginsi* is merely a local form of *L. orbiculata,* the form of very large rivers with muddy bottoms. We have repeatedly seen in other species that inflation of the beaks is a character of big-river-forms. If this is another case of this kind, the relation of the Ouachita and Black River *orbiculata* to that of the Ohio could be explained as that of an ecological race. Of course, additional material should be studied. That there might be intergrades is indicated by our specimens from Muscatine, which incline somewhat toward *higginsi*

[209] As far as I can see *L. higginsi* (Lea) differs from *L. orbiculata* chiefly in the more inflated and more elevated beaks, and in the color of the epidermis, which has more green in it.

by their slightly more elevated beaks and their more brownish-olive epidermis, and by specimens of the same character from Black River, as well as by a specimen from the Mississippi at Andulusia, received together with typical *orbiculata*.

## Genus Truncilla Rafinesque (1820).

Ortmann, 1912, p. 354; Simpson, 1914, p. 2.

Type *Truncilla triquetra* Rafinesque.

Simpson (1900) has divided the genus into four subgenera (*Truncilla, Scalenaria, Dysnomia, Pilea*) while Walker (1910) in a recent revision of the genus, admits three main groups, which properly might be regarded as subgenera. Investigations of the soft parts, however, probably will require some alterations of this arrangement. I prefer to ignore the subgenera for the present, since there are only two species in Pennsylvania, the first one (*triquetra*) being a true *Truncilla*, while the second (*rangiana*) would fall under Simpson's *Pilea*. The rest of the species are chiefly found in the Tennessee-Cumberland region.

Key to the Pennsylvanian Species of Truncilla.

$a_1$. Shell with a very distinct posterior ridge, and distinctly truncate posterior slope. Inflation of female shell narrow, very convex, restricted to the posterior ridge, not differing from the rest of the shell in texture, and denticulated on the margin. Rays strongly spotted................ *T. triquetra.*

$a_2$. Shell with a very indistinct posterior ridge, and the posterior slope not truncate. Inflation of the female shell very broad and flat, occupying the whole postbasal area, with the nacreous layer poorly developed, not denticulated on the margin. Rays simple, not spotted............. *T. rangiana.*

### Truncilla triquetra Rafinesque (1820).

*Truncilla triquetra* Rafinesque, Simpson, 1914, p. 5.

Plate XXI, figs. 3, 4.

*Records from Pennsylvania:*

Rhoads, 1899 (Ohio River, Coraopolis, Allegheny Co., and Beaver, Beaver Co.; Beaver River, Wampum, Lawrence Co.)

Ortmann, 1909*b*, p. 188.

*Characters of the shell:* Small, moderately thick. Outline subovate to subtrapezoidal and subtriangular. Anterior margin rounded. Lower margin gently curved, but sometimes (chiefly in the female) straight or even slightly emarginate posteriorly. Upper margin very short, passing in old specimens into the obliquely descending posterior margin without forming an angle (shape triangular), but in young specimens there is generally an angle (shape trapezoidal). Posterior margin forming a rather distinct, but more or less rounded, angle with the lower margin. This angle is situated very low, only a little elevated above the base-line. Beaks

moderately swollen, and moderately elevated above the hinge-line, located in front of the middle of the shell, but not very near the anterior end. Beak-sculpture rudimentary, consisting of about three faint, indistinct bars, which have a tendency to fall into two loops. Valves greatly swollen, but rather flat upon the sides, convex anteriorly, and with a very distinct and strong, but blunt, posterior ridge; no furrow or depression in front of the latter. Behind the posterior ridge the posterior slope is sharply truncate and flat, being very little elevated in the middle.

Epidermis yellowish, yellowish green, or light green, always with well developed dark green to blackish rays, which are distinct, broad and bold, and generally have the tendency to become dissolved into squarish, triangular, or sagittate spots. In most cases the rays cover all of the lateral faces of the shell, but they are indistinct or entirely absent on the posterior slope. In old specimens the rays disappear toward the lower margin. Concentric bands of color are indicated chiefly by a tendency to have the spots of the rays arranged in concentric lines.

Hinge well-developed. Pseudocardinals generally two in each valve, but the anterior tooth in the right valve is small. The teeth are strong, stumpy, ragged. Interdentum absent. Laterals of medium length, strong. Beak-cavity moderate. Dorsal muscle-scars in beak-cavity. Adductor-scars distinct, and anteriorly strongly impressed, less so posteriorly. Nacre always silvery white.

Sexual differences of the shell very strongly marked. The male has a rather regular, subtriangular outline, with the posterior ridge moderately elevated, the greatest diameter of the shell situated slightly in front of the ridge, and with a moderately broad posterior slope, without sculpture, and with the edge of the shell entire. In the female the marsupial expansion is located on and restricted to the posterior ridge. In consequence of this the posterior ridge is greatly elevated, and the greatest diameter of the shell is located upon the posterior ridge, and in old females the diameter of the shell often exceeds the height of the shell (a proportion quite unique among Naiades). The posterior slope in the female is greatly enlarged, and in addition there is a sculpture of radial ribs upon the posterior ridge and posterior slope, which produces a denticulation on the margin of the shell in this region. This sculpture may be present, in a rudimentary condition, in old males. The general outline of the female shell is a little different, the posterior end projecting slightly beyond the line of the lower margin, so that there is a slight concavity of the lower margin in front of the posterior end. The female shell does not nearly attain the size of the male shell.

| | | L. | H. | D. |
|---|---|---|---|---|
| *Size:* (Males) | 1. Kelly, Cat. No. 61.2983 | 68 mm. | 44 mm. | 36 mm. |
| | 2. Shenango, Cat. No. 61.4097 | 60 " | 41 " | 31 " |
| | 3. Aladdin, Cat. No. 61.3358 | 52 " | 34 " | 25 " |
| | 4. do. " " do. | 40 " | 27 " | 20 " |
| (Females) | 5. Kelly, Cat. No. 61.2985 (gravid) | 45 " | 25 " | 28 " |
| | 6. Aladdin, Cat. No. 61.3358 (gravid) | 42 " | 26 " | 31 " |
| | 7. Aladdin, Cat. No. 61.3358 (gravid) | 38 " | 22 " | 19 " |
| | 8. Godfrey, Cat. No. 61.3360 (gravid) | 37 " | 22 " | 18 " |

The largest individuals recorded here are not surpassed by any specimens from outside of Pennsylvania.

*Soft parts* (See Ortmann, 1912, p. 355, fig. 27). *Glochidia* (See Ortmann, 1911, Pl. 89, fig. 24).

*Breeding season:* Gravid females were found on Sept. 5, 1913; Sept. 8, 1914; Sept. 15, 1913; Sept. 16, 1913; Sept. 17, 1913; Sept. 18, 1908; Sept. 27, 1907; Sept. 27, 1909; Oct. 5, 1908; Then again on May 20, 1914; May 23, 1911; May 24, 1911.

Glochidia have been observed as early as Sept. 17. On May 20 and 23, discharging females have been found. Thus this species is clearly *bradytictic.*

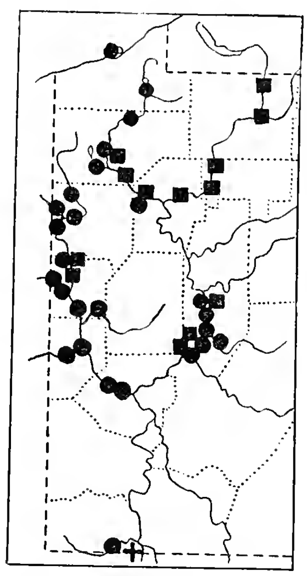

FIG. 34.

● *Truncilla triquetra.*

■ *Truncilla rangiana.*

+ Do. (Indian garbage heap).

*Remarks:* The female of this species is so peculiar in shape and color, and in possessing the remarkable character of denticulations on the margin of the shell,

that it cannot be confounded with any other species. The male also is quite well-defined by its subtriangular shape, strong posterior ridge, and truncate posterior slope, and also its color-pattern. However, to a certain degree the male resembles *Amygdalonaias truncata* (Rafinesque) but the latter is a higher and more compressed shell, with the posterior ridge sharper, chiefly in the region of the beaks, and with the posterior slope narrower and less distinctly truncate.

There is a good deal of variation in the shell of *Truncilla triquetra*. Aside from the general outline, which is more subtrapezoidal in young shells, and more subtriangular in old ones, there is variation in the elongation of the shell. In old males the posterior end is often considerably drawn out. Both males and females vary greatly in diameter and in the width of the posterior slope, which in some old females becomes really freakish. There is also great variation in the color-pattern, and the rays and the spots are hardly ever alike in any two specimens.

The Lake Erie form of this species does not seem to differ from the normal type. I have only few specimens from the lake, which compared with specimens from the Ohio are of about medium size, and seem to be slightly lighter in color.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Ohio River, Neville Island, Allegheny Co.[210]
Beaver River, Wampum, Lawrence Co. (G. H. Clapp & H. H. Smith).[211]
Mahoning River, Mahoningtown and Edinburg, Lawrence Co.
Shenango River, Pulaski, Lawrence Co.; Sharpsville, Clarksville, and Shenango, Mercer Co.
Pymatuning Creek, Pymatuning Township, Mercer Co.
Allegheny River, Aladdin, Godfrey, Johnetta, Kelly, Mosgrove, and Templeton, Armstrong Co.
Crooked Creek, Rosston, Armstrong Co.
French Creek, Utica, Venango Co.; Meadville and Cambridge Springs, Crawford Co.
Conneaut Outlet, Conneautlake, Crawford Co.
Leboeuf Creek, Waterford, Erie Co.
Dunkard Creek, Mount Morris, Greene Co.
Lake Erie, Presque Isle Bay, Erie, Erie Co.

*Other localities represented in the Carnegie Museum:*

*Lake-drainage:*

Sandusky River, Fremont, Sandusky Co., Ohio (C. Goodrich).
Swan Creek, Toledo, Lucas Co., Ohio (C. Goodrich).

*Ohio-drainage:*

Ohio River, Portland, Meigs Co., Ohio.
Tuscarawas River, Ohio (Holland collection).
Miami River, Ohio (Juny collection).

[210] A dead shell has been seen at Industry, Beaver Co.
[211] A dead shell has been seen in Slipperyrock Creek, at Wurtemberg, Lawrence Co.

Big Beaver Creek, Mercer Co., Ohio (C. Goodrich) (Wabash-drainage).

West Fork River, Lynch Mines, Harrison Co.; West Milford, Harrison Co. (W. F. Graham); Lightburn, Lewis Co., West Virginia.

Little Kanawha River, Grantsville, Calhoun Co. (W. F. Graham); Burnsville, Braxton Co., West Virginia.

North Fork Hughes River, Cornwallis, Ritchie Co., West Virginia.

*Tennessee-drainage:*

Duck River, Columbia, Maury Co., Tennessee (G. H. Clapp, donor).

Tennessee River, Florence, Lauderdale Co., Alabama (H. H. Smith).

Bear Creek, Burleson, Franklin Co., Alabama (H. H. Smith).

Flint River, Maysville, Madison Co., Alabama (H. H. Smith).

Paint Rock River, Paint Rock, Jackson Co., Alabama (H. H. Smith).

Nolichucky River, Chunns Shoals, Hamblen Co., Tennessee.

Holston River, McMillan and Mascot, Knox Co.; Turley Mill and Holston Station, Grainger Co.; Austin Mill, Hawkins Co., Tennessee.

South Fork Holston River, Pactolus, Sullivan Co., Tennessee.

North Fork Holston River, Rotherwood, Hawkins Co., Tennessee; Hilton, Scott Co., Virginia; Mendota, Washington Co., Virginia.

Clinch River, Solway, Knox Co.; Edgemoor and Clinton, Anderson Co.; Black Fox Ford, Union Co.; Clinch River Station, Claiborne Co.; Oakman, Grainger Co., Tennessee; Speers Ferry and Clinchport, Scott Co., Virginia.

Powell River, Combs, Claiborne Co., Tennessee.

*Distribution and Ecology in Pennsylvania* (See fig. 34): This is a widely distributed species in the Ohio-drainage in western Pennsylvania, but is not found anywhere in great numbers. In the Ohio proper below Pittsburgh I found only a few dead shells. It is present in the Beaver-drainage, but is not very abundant. In the Allegheny in Armstrong Co. it is not rare, and in this region enters some of the tributaries, as Crooked Creek, and farther up, French Creek, penetrating well into the headwaters. It has not been found in the Allegheny above Oil City.

In the Monongahela-drainage, this species is extremely rare, and I found it only in Dunkard Creek. However, farther up in the headwaters in West Virginia it is rather abundant, as in West Fork River, where at Lynch Mines I secured the largest number of specimens in all my collecting.

In addition this species is present in Lake Erie, but here it is extremely rare. I found only a single dead shell in Presque Isle Bay.

*Truncilla triquetra* distinctly belongs to those species, which inhabit riffles. Wherever I found it, it was on riffles, and (at low stage) in quite shallow water, in strong currents. Here it is deeply buried, and only the truncated posterior slope is exposed, so that in the natural position the shell offers a very peculiar aspect; only the flat, broadly lanceolate posterior slope is exposed to view, differing entirely from the dark slit generally seen in other Naiades (formed by the

anal and branchial openings). The bottom at these localities generally consists of finer or coarser, closely packed gravel; but I have also found this species in pure sand, when the latter is not kept moving by the current. In Lake Erie, in Presque Isle Bay, of course, this species must live in the fine sand of the bay: but I did not find it alive there.

*General distribution: Type locality,* Falls of the Ohio (Rafinesque) (at Louisville, Jefferson Co., Kentucky).

Simpson (1900) gives the following range: "Ohio River-drainage; western New York to southern Michigan; Iowa; eastern Nebraska to Indian Territory." In the Ohio-drainage, this species is generally distributed, not only in the Ohio proper, where it seems to be scarce, but also, and chiefly so, in the tributaries. It goes rather far up in the smaller streams. From Pennsylvania it goes through West Virginia and Ohio to Indiana and Illinois. Here it goes up into the Kankakee River and to Will Co. (Baker, 1906), but is not in the "Chicago area."

Records from the southern tributaries of the Ohio in Kentucky are scarce, but it is in the upper Cumberland and its tributaries (Wilson & Clark, 1914), and in the Tennessee to northern Alabama and eastern Tennessee, where it reaches, in the Clinch and North Fork of the Holston River, into the state of Virginia.

Farther to the west, it has been reported from the Mississippi River in Iowa (Pratt, 1876; Witter, 1878; Marshall, 1895), but not farther north. Simpson records it from eastern Nebraska, and it exists in eastern Kansas (Scammon, 1906), and also, according to Simpson, in Oklahoma. However, there are no records from Missouri (see Utterback, 1916) and Arkansas, and southward, and none from the Alabama-drainage.

*T. triquetra* has, however, crossed over into the lake-drainage, and it is found in this drainage in Ohio (Sterki, 1907*a*), in southern Michigan (Walker, 1898), and in Lake Erie (Walker, 1913). Here it goes eastward to the state of New York, and the locality "New York" (Call, 1885; Simpson, 1900) is supported only by definite records from Buffalo and Niagara River (see Marshall, 1895).[212]

As in Pennsylvania so elsewhere this species seems to prefer riffles, with rough bottoms and strong currents.

[212] It might be in the upper Allegheny in New York, but, as has been said, I never found it in the Allegheny above Oil City.

TRUNCILLA RANGIANA (Lea) (1838).

*Truncilla perplexa rangiana* (LEA) SIMPSON, 1914, p. 25.[213]

Plate XXI, figs. 5, 6, 7.

*Records from Pennsylvania:*

Marshall, 1895 (as *U. perplexus* Lea from the Allegheny River, Warren Co.; this undoubtedly is *T. rangiana*).

Ortmann, 1909*b*, p. 188.

*Characters of the shell:* Shell rather small (but larger than that of *T. triquetra*), moderately thick, but extremely thin at the postbasal expansion of the female. Outline irregularly subovate. Anterior margin rounded. Lower margin of the male convex in front, straight or concave, and ascending in the posterior part; this posterior part forms a blunt, more or less distinct angle with the anterior part. In the female the lower margin forms a more or less distinctly double curve, the posterior part more strongly convex, and the two parts are separated by a short concavity or notch. Upper margin moderate, passing in a blunt angle or gradually into the obliquely descending posterior margin. In the male the posterior and lower margins meet in a blunt posterior point, which is situated well above the basal line; in the female the posterior end of the shell is broadly and evenly rounded. Beaks not much swollen, and little elevated above the hinge-line, located in front of the middle of the shell, and only a short distance away from the anterior end. Beak-sculpture rudimentary, consisting of three or four faint bars, which are double-looped. Valves rather compressed, moderately and rather evenly convex in the anterior part of the shell. In the male there is a blunt and indistinct posterior ridge, and in front of this a broad and shallow radial furrow, running from the beak to the posterior part of the lower margin. In front of this furrow the shell is often somewhat elevated, forming a blunt rib running toward the angle in the middle of the lower margin. Posterior slope narrow, gently convex or flattened, not truncate. In the female the region of the furrow and of the posterior ridge is occupied by a broad and somewhat flattened expansion, in front of which there is a more or less distinct, narrow constriction in old specimens. Posterior ridge and posterior slope entirely indistinguishable in the female.

Epidermis yellow or greenish olive, generally with rather distinct, fine, and crowded, straight and uninterrupted, dark green rays. These rays may cover practically the whole surface, but in old specimens they disappear toward the lower margin and upon the posterior expansion, which often is of a lighter color

[213] *U. gubernaculum* Reeve, 1865, Pl. 28, fig. 146, is not this form, as Simpson believes, but a variety of *T. torulosa* (Rafinesque) (= *perplexa* Lea) found in the headwaters of the Tennessee River.

than the rest of the surface. Concentric dark bands, marking growth-rests, are more or less distinct.

Hinge well-developed. Pseudocardinals two in left, one or two in right valve, stumpy, ragged. Interdentum absent. Laterals moderately long, moderately strong. Beak-cavity rather shallow. Dorsal muscle-scars in beak-cavity. Adductor-scars distinct and well impressed, chiefly those in front. Nacre always white.

Sexual differences in the shell extremely great. The general form of the male shell is ovate, somewhat pointed posteriorly, with a rather distinct posterior ridge and a radial furrow in front of it. The female shell is also ovate, but the wider part is behind, and it is not at all pointed at the posterior end, but broadly rounded. The place of the radial furrow is filled by a broad postbasal expansion, which may occupy the whole posterior half of the shell, and from the anterior part, this is marked off, in old specimens, by a more or less distinct constriction. In young females (Pl. XXI, fig. 6), this postbasal expansion is less developed, and the shell is only slightly thinner here than the rest of it. But in old females this expansion is greatly developed, and is very thin, since the deposition of nacreous matter ceases here, and thus the expansion appears chiefly horny (epidermis), with a thin film of prismatic matter. The females grow practically to the same size as the males.

| | | | L. | H. | D. |
|---|---|---|---|---|---|
| *Size:* | (Males) | 1. Meadville, Cat. No. 61.3362 | 72 mm. | 50 mm. | 31 mm. |
| | | 2. Cochranton, Cat. No. 61.3363 | 70 " | 50 " | 33 " |
| | | 3. do. " " do. | 61 " | 46 " | 29 " |
| | | 4. do. " " do. | 45 " | 33 " | 22 " |
| | | 5. Utica, Cat. No. 61.3368 | 37 " | 28 " | 19 " |
| | (Females) | 6. Warren, Cat. No. 61.3979 | 70 " | 45 " | 32 " |
| | | 7. Cochranton, Cat. No. 61.3363 (gravid) | 65 " | 43 " | 30 " |
| | | 8. Hickory, Cat. No. 61.3366 (gravid) | 62 " | 42 " | 25 " |
| | | 9. Cochranton, Cat. No. 61.3363 | 51 " | 36 " | 25 " |
| | | 10. Harbor Bridge, Cat. No. 61.3372 | 36 " | 26 " | 17 " |

*Soft parts* (See Ortmann, 1912, p. 358, fig. 28). *Glochidia* (See *ibid.*) similar to those of *T. perplexa* Lea (Obs. VI, 1858, Pl. 5, fig. 21) (= *torulosa* Rafinesque).

*Breeding season:* Gravid females were collected on Sept. 2, 1908; Sept. 5, 1908; Sept. 6, 1908; Sept. 15, 1909; Sept. 18, 1908. On the first date young glochidia were already observed, and thus the beginning of the season probably falls early in August. The species probably is *bradytictic.*

*Remarks: T. rangiana* has been considered a variety of *T. torulosa* (Rafinesque) = *perplexa* Lea. The latter is not found in Pennsylvania. It is dis-

tinguished from *T. rangiana* by the presence of a radial row of tubercles upon the middle of the shell, standing in the male upon the radial rib, in the female in front of the marsupial expansion; and further *T. torulosa* has the postbasal expansion of the female dark green in color.

Slightly tuberculate specimens once existed in Pennsylvania, and I collected such in an Indian Garbage heap at Point Marion (Ortmann, 1909*c*). I have called them *T. cincinnatiensis*, but they are not the true *cincinnatiensis*, and are by no means the typical *T. torulosa*. Whether forms approaching the latter once existed in the Monongahela and Ohio cannot be now ascertained. All *living* shells from Pennsylvania are typical *rangiana*. Some specimens, indeed, show indications of tubercles, but these are rather indefinite, obscure swellings, the majority of the specimens being perfectly smooth.

The female of this species is easily recognized by the peculiar postbasal expansion. The male, however, has a shape which reminds of young *Plethobasus cyphyus*. But *P. cyphyus* has a lighter yellow epidermis, and has no rays. Moreover the beak-sculpture is quite different.

The range of variation has been already indicated in the description. Disregarding the slight tendency to show traces of tubercles in the middle of the shell, the radial furrow is somewhat variable, and also the angle in the middle of the lower margin. The postbasal expansion of the female is very variable, increasing with the age of the individual, but it always is of light color, not dark-green.

*Localities in Pennsylvania represented in the Carnegie Museum:*

Shenango River, Harbor Bridge and Pulaski, Lawrence Co.

Allegheny River, Aladdin, Godfrey, Johnetta, and Templeton, Armstrong Co.; Walnut Bend, Venango Co.; Tionesta and Hickory, Forest Co.; Warren, Warren Co.

French Creek, Utica, Venango Co.; Cochranton and Meadville, Crawford Co.

Connewango Creek, Russell, Warren Co.

*Other localities represented in the Carnegie Museum:*

West Fork River, Lynch Mines, Harrison Co., West Virginia.

Tuscarawas River, Ohio (Holland collection).

Columbus, Franklin Co., Ohio (Hartman collection) (Smith collection).

White River, Rockford, Jackson Co., Indiana (G. H. Clapp, donor) (Wabash-drainage).

*Distribution and Ecology in Pennsylvania* (See fig. 34): I have found this species in the Beaver-drainage in the Shenango River,[213a] where it is very rare

[213a] I have not seen it in the Mahoning River in Pennsylvania, although it has been reported from this river in Ohio (Lea, 1838; Dean, 1890).

(only three specimens taken), and in the Allegheny River from Armstrong County up to Warren County. It is also found in French and Connewango Creeks, tributaries of the Allegheny. In the Allegheny itself it is found rather regularly, but not in great numbers; it is most abundant in French Creek and at Cochranton it was a common species.

In the Monongahela-drainage I never found it alive, but its former occurrence there is indicated by shells from the Indian garbage heap at Point Marion. It also occurs farther up in the headwaters in West Virginia, but is very rare.

It is remarkable that this species has not turned up in the Ohio below Pittsburgh, and that there are no localities for it positively ascertained in the Ohio, until we reach Cincinnati.

I always found this species on riffles, perferably upon a bottom composed of firmly packed and rather fine gravel, in swiftly flowing, shallow water. In the Allegheny in Armstrong County I have also seen it in coarse gravel.

*General distribution: Type locality,* Ohio River, Cincinnati (Lea).

Aside from western Pennsylvania and the upper Monongahela in West Virginia, this species is known from the state of Ohio. In the Ohio proper only the type locality is known; but according to Sterki (1907*a*) it is found in the Mahoning, Tuscarawas, and Scioto Rivers. In Indiana it is found in the Ohio and Wabash (Call, 1896*a*), and in White River (Carnegie Museum) and in Illinois only in the southern portion (Wabash, see Baker, 1906). In addition it occurs in south-eastern Michigan, in the Lake Erie-drainage (Detroit and Raisin Rivers, see Walker, 1892 & 1898), and it is also given (Walker, 1913) in the Lake Erie list, but has never been found on the Pennsylvanian shores of the lake.

According to these records, this species is rather restricted in its range, and belongs to the Ohio River and its tributaries, chiefly the northern ones, and seems to have its metropolis in the smaller tributaries of the upper Ohio River in the states of Ohio and Pennsylvania. It also has crossed over into the lake-drainage, but particulars are lacking.

An allied species is *T. torulosa* (= *perplexa*), which seems to inhabit the lower Ohio and the Tennessee drainage. It is interesting to note that the latter develops in the upper Tennessee a compressed form without tubercles, which should be called *gubernaculum* Reeve, and which is a form parallel to *rangiana*, but has the dark green postbasal expansion of *torulosa*. This case should be kept in mind, for it is an interesting instance of the reactions of the Naiades to environmental conditions. The form most closely related to *T. rangiana* undoubtedly is *T. sampsoni* (Lea) of the lower Wabash, which differs only in having the shell more

swollen and the beaks more inflated. It possibly is only the big-river-form of *T. rangiana*.

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## EXPLANATION OF PLATE I.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

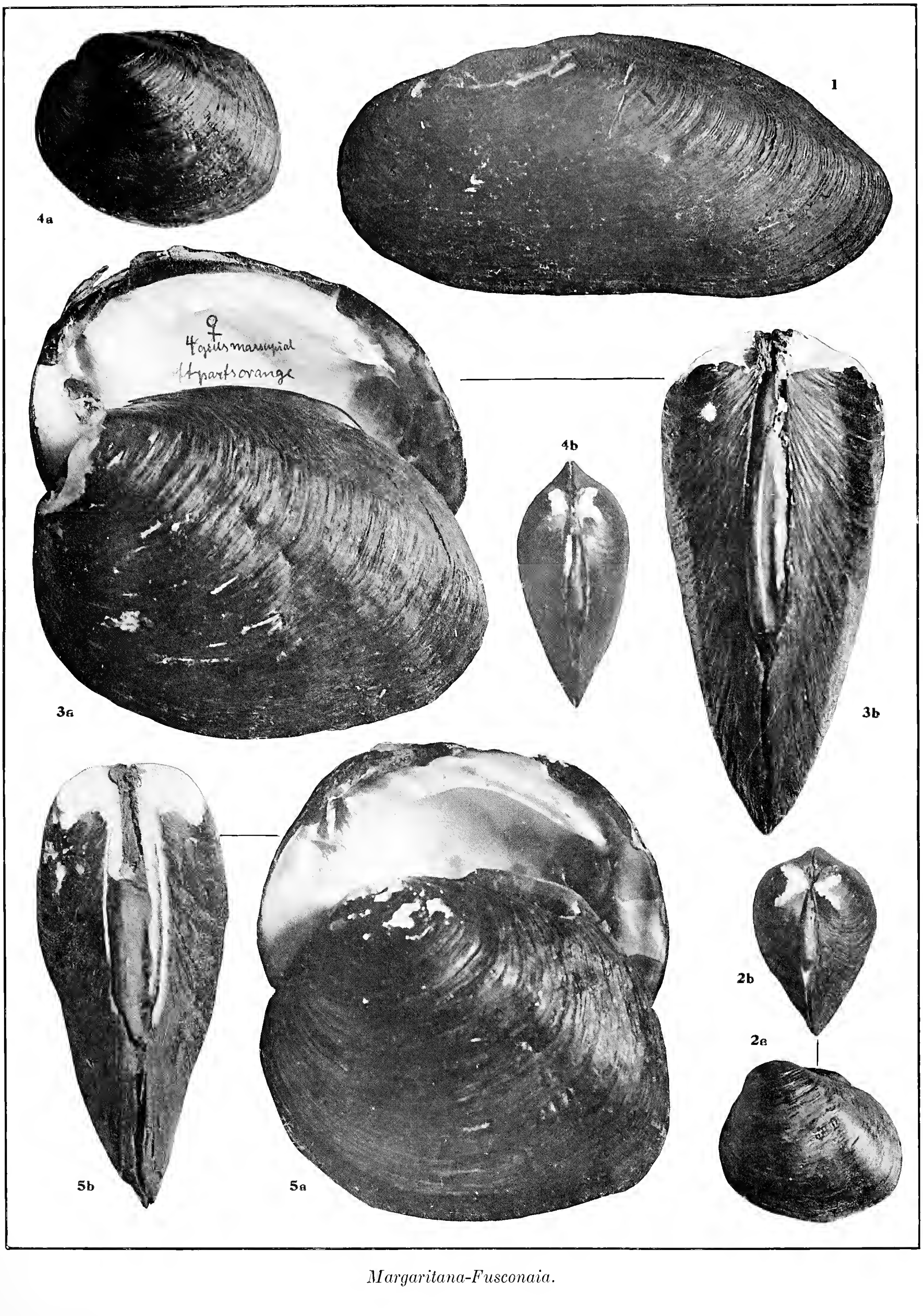
Fig. 1. *Margaritana margaritifera* (Linnæus). Normal specimen from Indian Run. Rene Mont, Schuylkill Co., Pennsylvania, collected May 4, 1909; C. M. Cat. No.61.4272,

Fig. 2. *Fusconaia subrotunda* (Lea). Young specimen of typical shape, diameter 64 per cent of length, from Allegheny River, Godfrey, Armstrong Co., Pennsylvania, collected October 5, 1908; C. M. Cat. No. 61.3941*a*.

Fig. 3. *Fusconaia subrotunda kirtlandiana* (Lea). Old female, diameter 45 per cent of length, slightly drawn out posteriorly, from Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected August 5, 1913; C. M. Cat. No. 61.6462.

Fig. 4. *Fusconaia subrotunda kirtlandiana* (Lea). Typical young specimen, diameter 45 per cent of length. May be regarded as a topotype, from Mahoning River, Mahoningtown, Lawrence Co., Pennsylvania, collected August 4, 1908; C. M. Cat. No. 61.3921.

Fig. 5. *Fusconaia subrotunda kirtlandiana* (Lea). Adult specimen representing the typical phase, diameter 42 per cent of length, also topotype from Mahoning River, Mahoningtown, Lawrence Co., Pennsylvania, collected October 15, 1908; C. M. Cat. No. 61.3928.




*Margaritana-Fusconaia.*

## EXPLANATION OF PLATE II.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

FIG. 1. *Fusconaia flava trigona* (Lea). Typical specimen of this form, diameter 66 per cent of length, from Monongahela River, Charleroi, Washington Co., Pennsylvania, collected by G. A. Ehrmann; C. M. Cat. No. 61.5869*b*.

FIG. 2. *Fusconaia flava parvula* Grier. Male, from the type-set, diameter 52 per cent of length, from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected July 8, 1910; C. M. Cat. No. 61.4513.

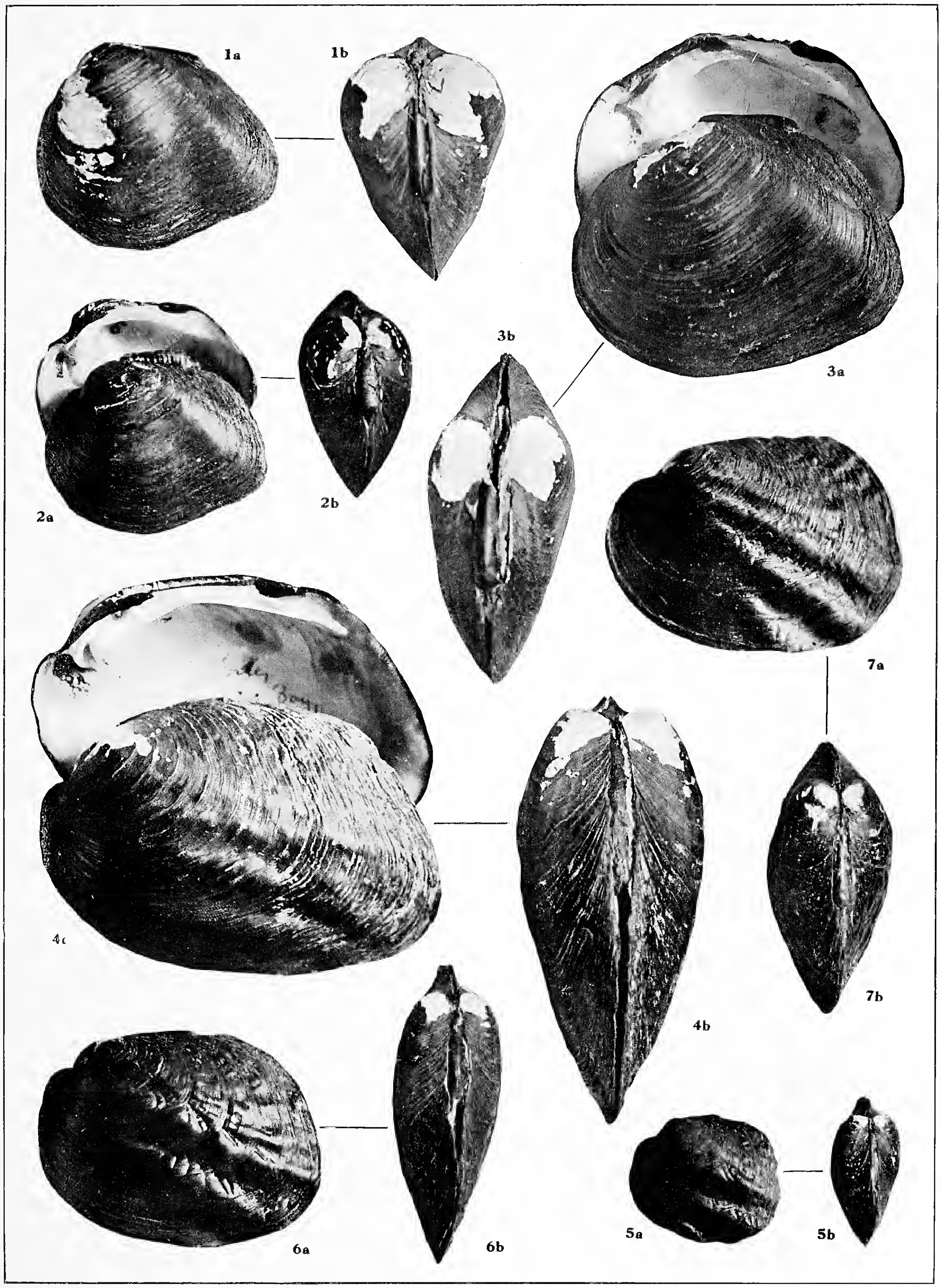
FIG. 3. *Fusconaia flava* (Rafinesque). Typical specimen, diameter 42 per cent of length, from Raccoon Creek, New Sheffield, Beaver Co., Pennsylvania, collected October 11, 1907; C. M. Cat. No. 61.3151.

FIG. 4. *Amblema plicata* (Say). Old full-grown specimen of the typical *plicata* from the type-locality, Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected June 3, 1908; C. M. Cat. No. 61.3336.

FIG. 5. *Amblema plicata* (Say). Young specimen, topotype, from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected July 8, 1910; C. M. Cat. No. 61.4518.

FIG. 6. *Amblema plicata* (Say). Specimen of medium size, unusually compressed, topotype from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected July 8, 1910; C. M. Cat. No. 61.4518.

FIG. 7. *Amblema plicata costata* (Rafinesque). Rather young specimen of the much compressed form of the small creeks, from French Creek, Cambridge Springs, Crawford Co., Pennsylvania, collected September 13, 1909; C. M. Cat. No. 61.4348.




*Fusconaia-Amblema.*

## EXPLANATION OF PLATE III.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

Fig. 1. *Amblema plicata costata* (Rafinesque). Typical, gravid female, of good size, representing the compressed creek-form, from Pymatuning Creek, Pymatuning Township, Mercer Co., Pennsylvania, collected July 8, 1909; C. M. Cat. No. 61.4340.

Fig. 2. *Amblema plicata costata* (Rafinesque). Exceptional specimen, without oblique undulations, also distinctly more swollen than the normal form, from the Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected August 3, 1908; C. M. Cat. No. 61.3829.

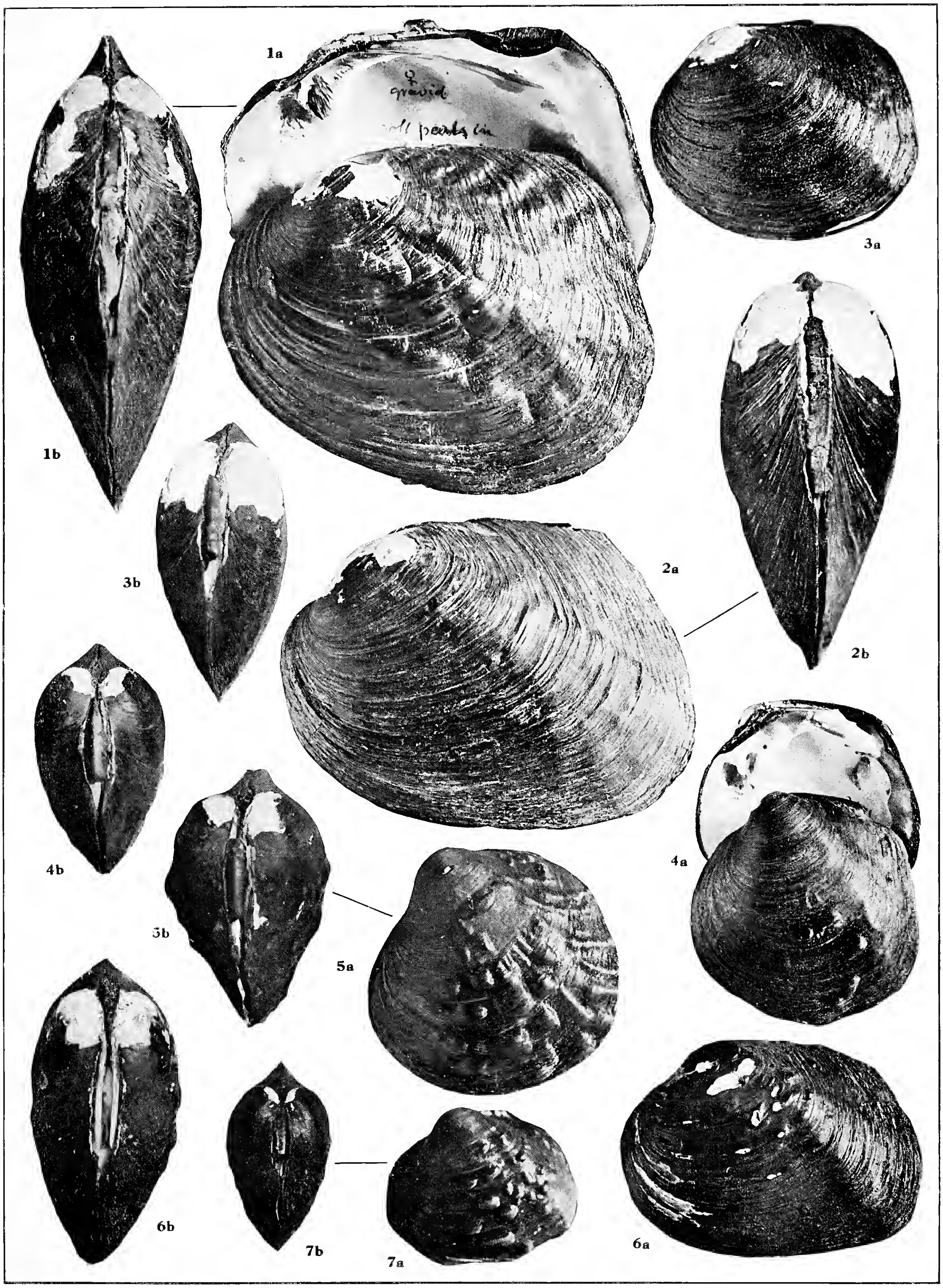
Fig. 3. *Amblema plicata costata* (Rafinesque). Young specimen with undulations nearly obliterated, also somewhat swollen, from Ohio River, Cook's Ferry, Beaver Co., Pennsylvania, collected October 8, 1909; C. M. Cat. No. 61.4428.

Fig. 4. *Quadrula pustulosa* (Lea). Specimen with few tubercles, from the Mahoning River, Edinburg, Lawrence Co., Pennsylvania, collected September 15, 1908; C. M. Cat. No. 61.3875.

Fig. 5. *Quadrula pustulosa* (Lea). Specimen with numerous tubercles, from Ohio River, Industry, Beaver Co., Pennsylvania, collected October 22, 1908; C. M. Cat. No. 61.3878.

Fig. 6. *Quadrula pustulosa schoocraftensis* (Lea). Old female, unusually transverse, from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected July 8, 1910; C. M. Cat. No. 61.4515

Fig. 7. *Quadrula pustulosa schoolcraftensis* (Lea). Female of medium size and rather normal shape, from Lake Erie, Cedar Point, Erie Co., Ohio, collected by Chas. Brookover, August 1909; C. M. Cat. No. 61.4451.




*Amblema-Quadrula.*

## EXPLANATION OF PLATE IV.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

FIG. 1. *Quadrula quadrula* (Rafinesque). Only specimen ever found in the Ohio in Pennsylvania, from Ohio River, Cook's Ferry, Beaver Co., Pennsylvania, collected September 10, 1908; C. M. Cat. No. 61.3869.

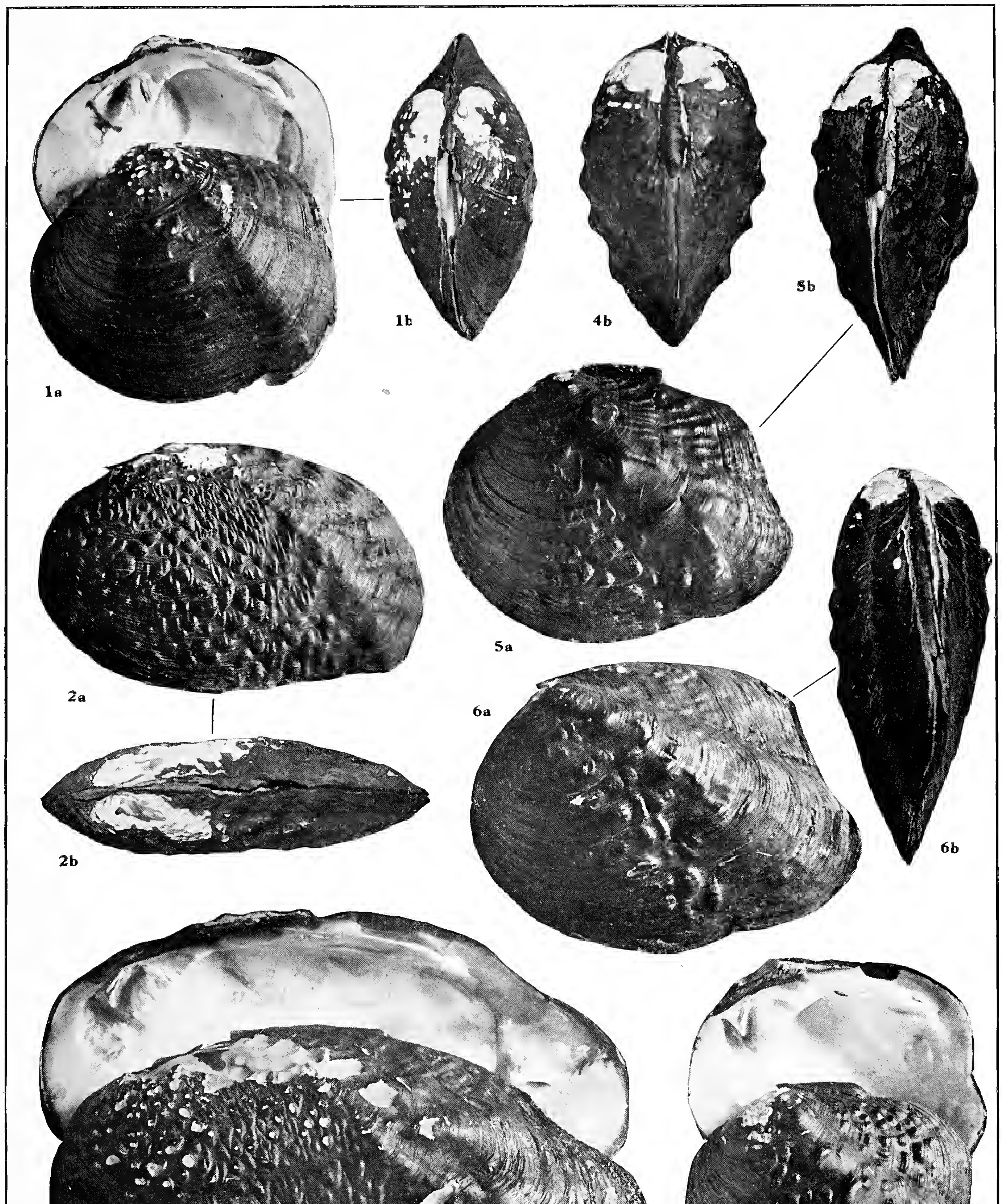
FIG. 2. *Quadrula verrucosa* (Rafinesque). Male of medium size, from Shenango River, Pulaski, Lawrence Co., Pennsylvania, collected July 19, 1909; C. M. Cat. No. 61.4121.

FIG. 3. *Quadrula verrucosa* (Rafinesque). Rather large female, from Shenango River, Pulaski, Lawrence Co., Pennsylvania, collected July 19, 1909; C. M. Cat. No. 61.4121.

FIG. 4. *Quadrula metanevra* (Rafinesque). Normal specimen from Ohio River, Industry, Beaver Co., Pennsylvania, collected September 25, 1908; C. M. Cat. No. 61.3865.

FIG. 5. *Quadrula metanevra* (Rafinesque). Specimen intergrading toward the var. *wardi* (Lea), with the tubercles moderately developed and the shell slightly more compressed, from Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected September 27, 1907; C. M. Cat. No. 61.3071.

FIG. 6. *Quadrula metanevra* (Rafinesque). A rather typical *wardi* (Lea), strongly compressed and with the large tubercles obliterated, from the Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected August 3, 1908; C. M .Cat. No. 61.3861.




*Quadrula.*

## EXPLANATION OF PLATE V.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

FIG. 1. *Quadrula cylindrica* (Say). Normal individual, from the Allegheny River, Godfrey, Armstrong Co., Pennsylvania, collected August 10, 1909; C. M. Cat. No. 61.4358.

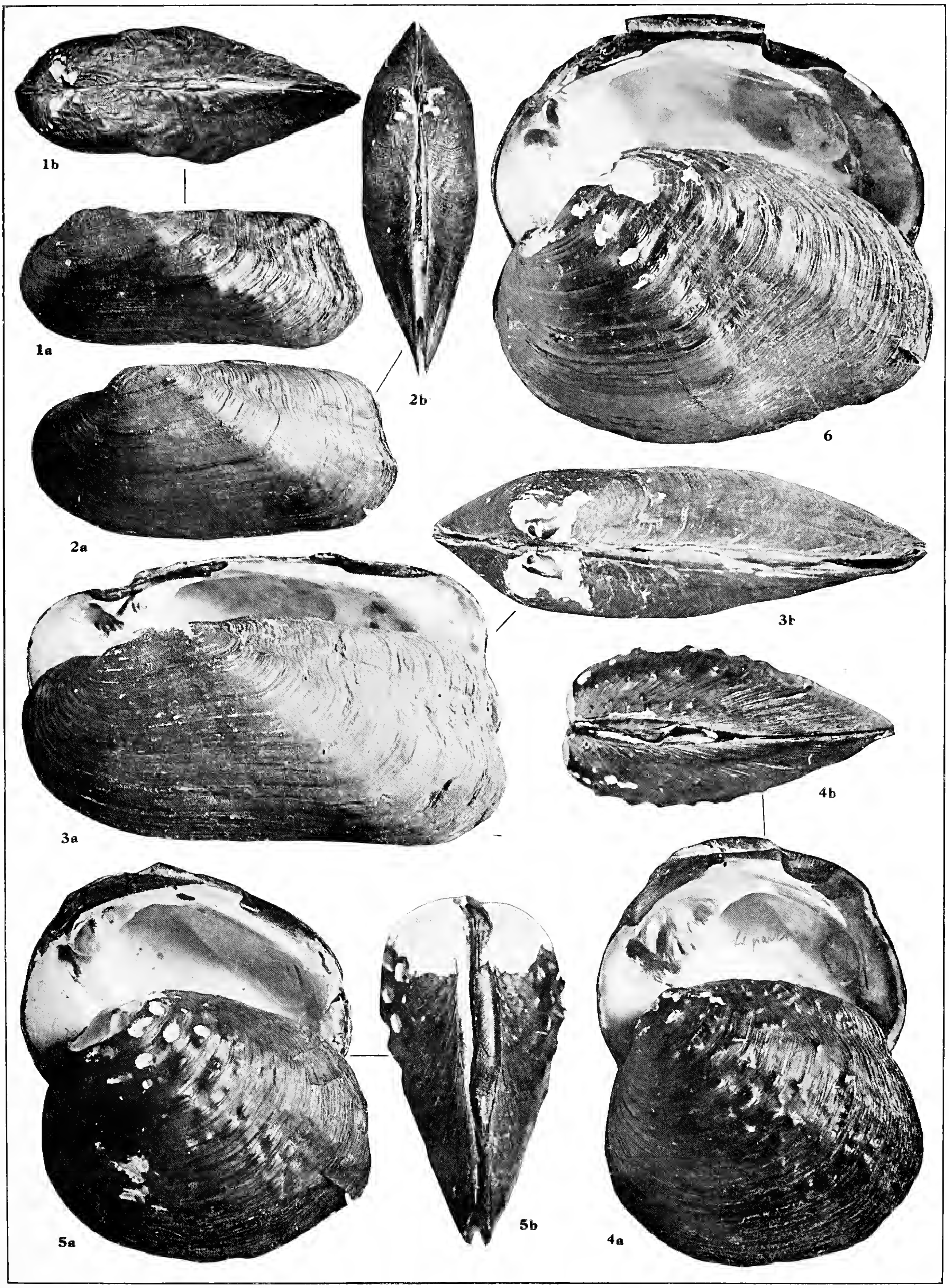
FIG. 2. *Quadrula cylindrica* (Say). Intergrade toward the smooth form, with tubercles greatly reduced, but shell not much compressed, from French Creek, Cochranton, Crawford Co., Pennsylvania, collected September 2, 1908; C. M. Cat. No. 61.3851.

FIG. 3. *Quadrula cylindrica* (Say). Smooth and compressed form, characteristic for the headwaters of the Ohio, from French Creek, Meadville, Crawford Co., Pennsylvania, collected September 1, 1908; C. M. Cat. No. 61.3850.

FIG. 4. *Rotundaria tuberculata* (Rafinesque). Female from the Allegheny River, Godfrey, Armstrong Co., Pennsylvania, collected August 10, 1909; C. M. Cat. No. 61.4411.

FIG. 5. *Plethobasus cooperianus* (Lea). Normal individual from the Ohio River, Industry, Beaver Co., Pennsylvania, collected October 22, 1908; C. M. Cat. No. 61.3882.

FIG. 6. *Plethobasus cyphyus* (Rafinesque). Large specimen of normal shape, from the Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected September 27, 1907; C. M. Cat. No. 61.3065.




*Quadrula-Rotundaria-Plethobasus.*

## EXPLANATION OF PLATE VI.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

Fig. 1. *Plethobasus cyphyus* (Rafinesque). Same specimen as the one figured on Plate V, fig. 6, from the Allegheny River; Kelly Armstrong Co., Pennsylvania, collected September 27, 1907; C. M. Cat. No. 61.3065.

Fig. 2. *Plethobasus cyphyus* (Rafinesque). Specimen of medium size, and rather short, from the Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected September 27, 1907; C. M. Cat. No. 61.3065.

Fig. 3. *Plethobasus cyphyus* (Rafinesque). Small specimen from the Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected September 27, 1907; C. M. Cat. No. 61.3065.

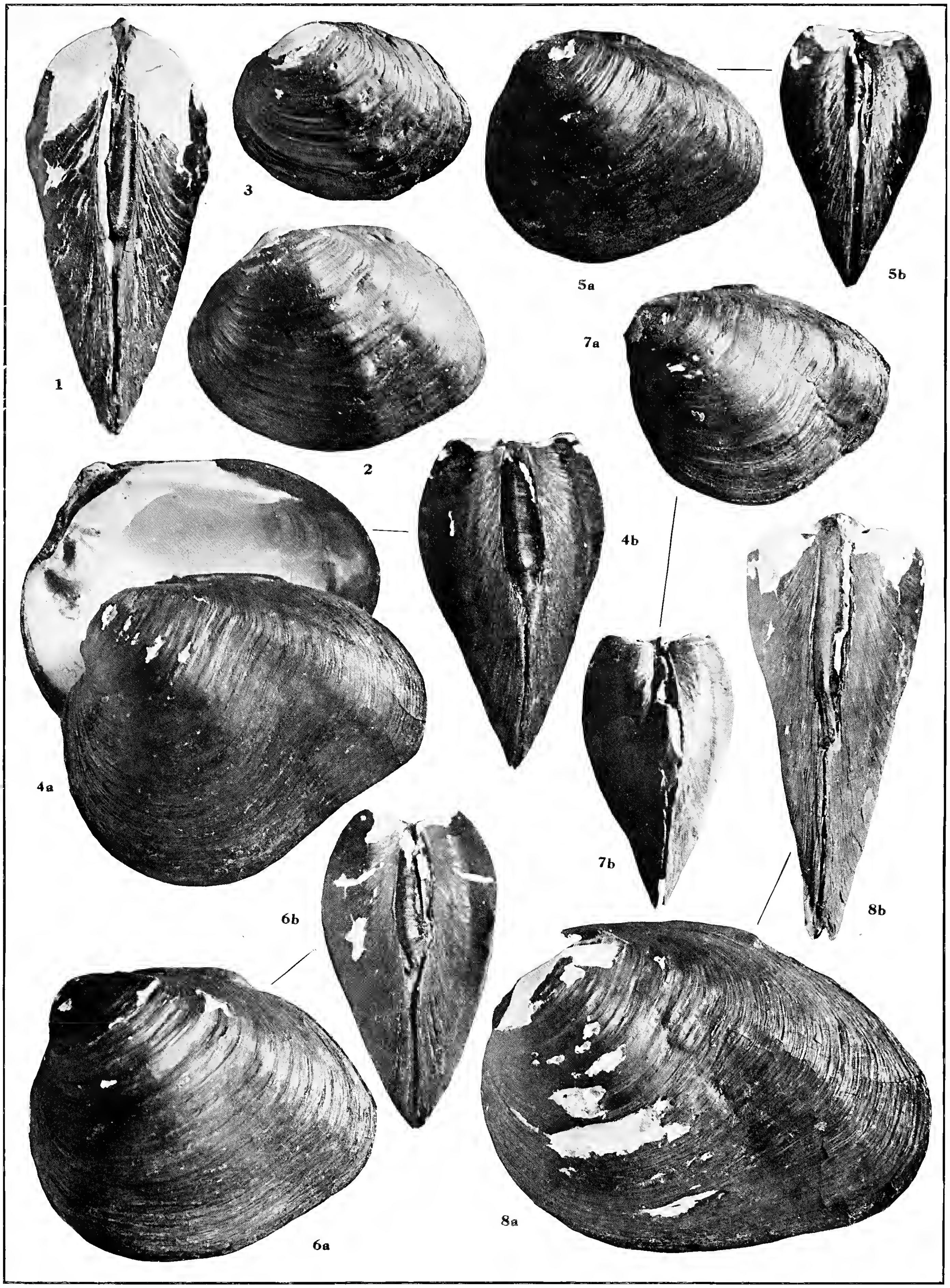
Fig. 4. *Pleurobema obliquum* (Lamarck). Normal form of the upper Ohio, diameter 55 percent of length, from the Ohio River, Industry, Beaver Co., Pennsylvania, collected October 3, 1908; C. M. Cat. No. 61.3900.

Fig. 5. *Pleurobema obliquum* (Lamarck). Specimen with weak furrow, inclining toward the var. *catillus* (Conrad), diameter 57 percent of length, from the Ohio River, Industry, Beaver Co., Pennsylvania, collected September 25, 1908; C. M. Cat. No. 61.3894.

Fig. 6. *Pleurobema obliquum catillus* (Conrad). A specimen closer to *catillus* than Fig. 5, diameter 56 percent of length, nacre pink. Specimens like those given in figs. 5 and 6 demonstrate that the two forms intergrade. From the Ohio River, Industry, Beaver Co., Pennsylvania, collected September 8, 1908; C. M. Cat. No. 61.3895.

Fig. 7. *Pleurobema obliquum rubrum* (Rafinesque). Rather typical, diameter 57 percent of length, from the Allegheny River, Godfrey, Armstrong Co., Pennsylvania, collected July 13, 1908; C. M. Cat. No. 61.3891.

Fig. 8. *Pleurobema obliquum* (Lamarck). Old specimen, drawn out posteriorly and consequently with the low diameter of 42 percent of the length; when young, this was a rather typical *obliquum*. From the Ohio River, Industry, Beaver Co., Pennsylvania, collected October 3, 1908; C. M. Cat. No. 61.3900.




*Plethobasus-Pleurobema.*

## EXPLANATION OF PLATE VII.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

FIG. 1. *Pleurobema obliquum cordatum* (Rafinesque). This specimen most closely approaches this form, but is not quite typical. From the Allegheny River, Godfrey, Armstrong Co., Pennsylvania, collected August 10, 1909; C. M. Cat. No. 61.4378.

FIG. 2. *Pleurobema obliquum catillus* (Conrad). Female, diameter 52 percent of length, approaching the var. *coccineum* (Conrad). From the Allegheny River, Godfrey, Armstrong Co., Pennsylvania, collected July 27, 1910; C. M. Cat. No. 61.4567.

FIG. 3. *Pleurobema obliquum coccineum* (Conrad). Large specimen, diameter 42 percent of length, from French Creek, Cambridge Springs, Crawford Co., Pennsylvania, collected September 13, 1909; C. M. Cat. No. 61.4394.

FIG. 4. *Pleurobema obliquum coccineum* (Conrad). Younger specimen, diameter 45 percent of length, from French Creek, Cambridge Springs, Crawford Co., Pennsylvania, collected September 13, 1909; C. M. Cat. No. 61.4394.

FIG. 5. *Pleurobema obliquum coccineum* (Conrad). Topotype, diameter 46 percent of length, from Mahoning River, Mahoningtown, Lawrence Co., Pennsylvania, collected August 4, 1908; C. M. Cat. No. 61.3907.

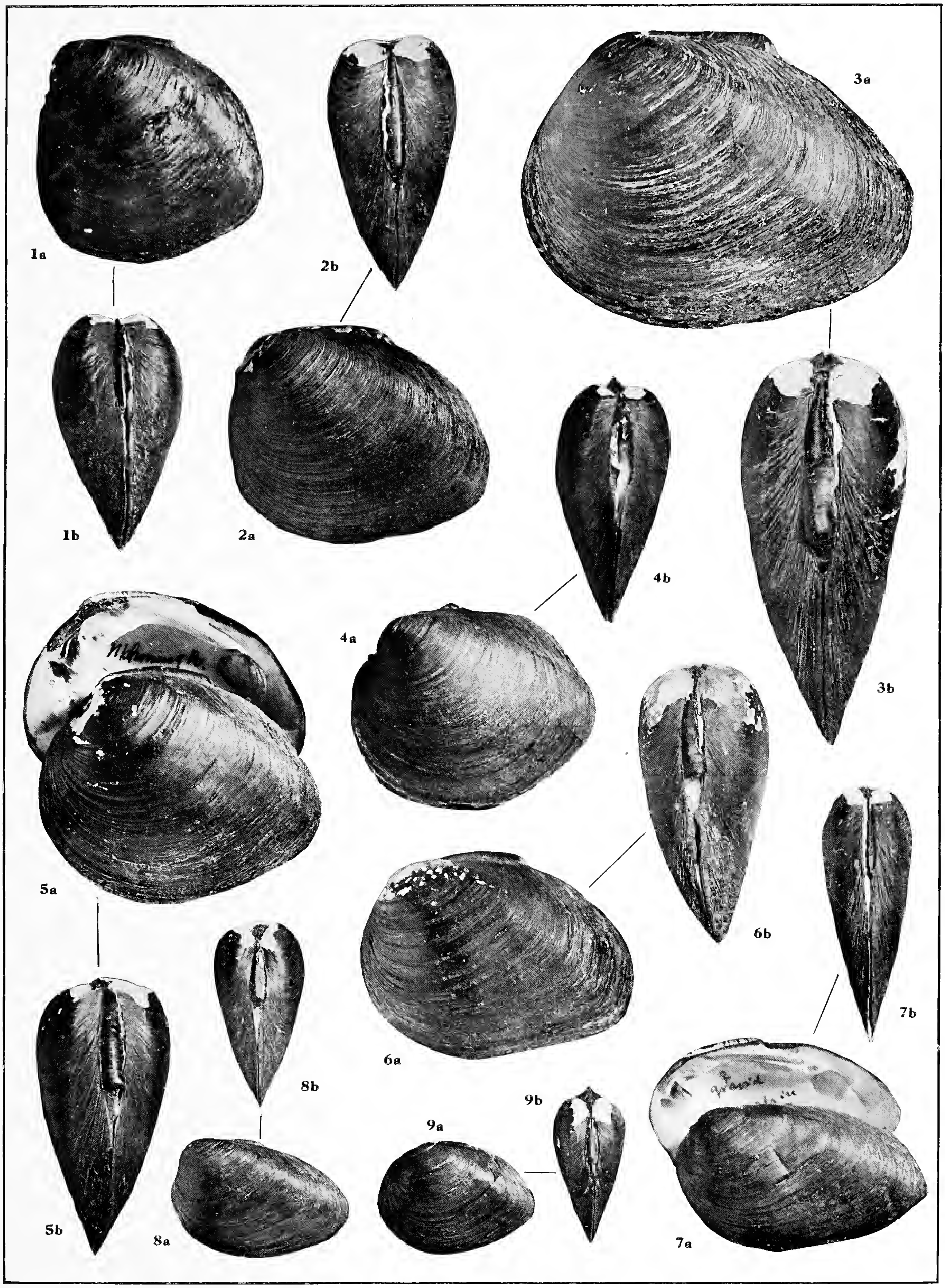
FIG. 6. *Pleurobema obliquum pauperculum* (Simpson). Typical, large specimen, diameter 47 percent of length, from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected May 21, 1909; C. M. Cat. No. 61.4398.

FIG. 7. *Pleurobema clava* (Lamarck). Large, gravid female from Neshannock Creek, Eastbrook, Lawrence Co., Pennsylvania, collected June 18, 1908; C. M. Cat. No. 61.3335.

FIG. 8. *Pleurobema clava* (Lamarck). Smaller specimen, very oblique, from Shenango River, Clarksville, Mercer Co., Pennsylvania, collected September 21, 1908; C. M. Cat. No. 61.3814.

FIG. 9. *Pleurobema clava* (Lamarck). Small specimen, much less oblique, from Shenango River, Clarksville, Mercer Co., Pennsylvania, collected September 21, 1908; C. M. Cat. No. 61.3814.

*Note:* The rays and blotches present in the specimens in figs. 7, 8, and 9, did not come out in the photographs.




*Pleurobema.*

## EXPLANATION OF PLATE VIII.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

Fig. 1. *Elliptio niger* (Rafinesque). Normal specimen of medium size, from the Ohio River, Industry, Beaver Co., Pennsylvania, collected September 8, 1908; C. M. Cat. No. 61.3781.

Fig. 2. *Elliptio dilatatus* (Rafinesque). Gravid female of medium size, diameter 29 percent of length, from the Allegheny River, Godfrey, Armstrong Co., Pennsylvania, collected July 27, 1910; C. M. Cat. No. 61.4618.

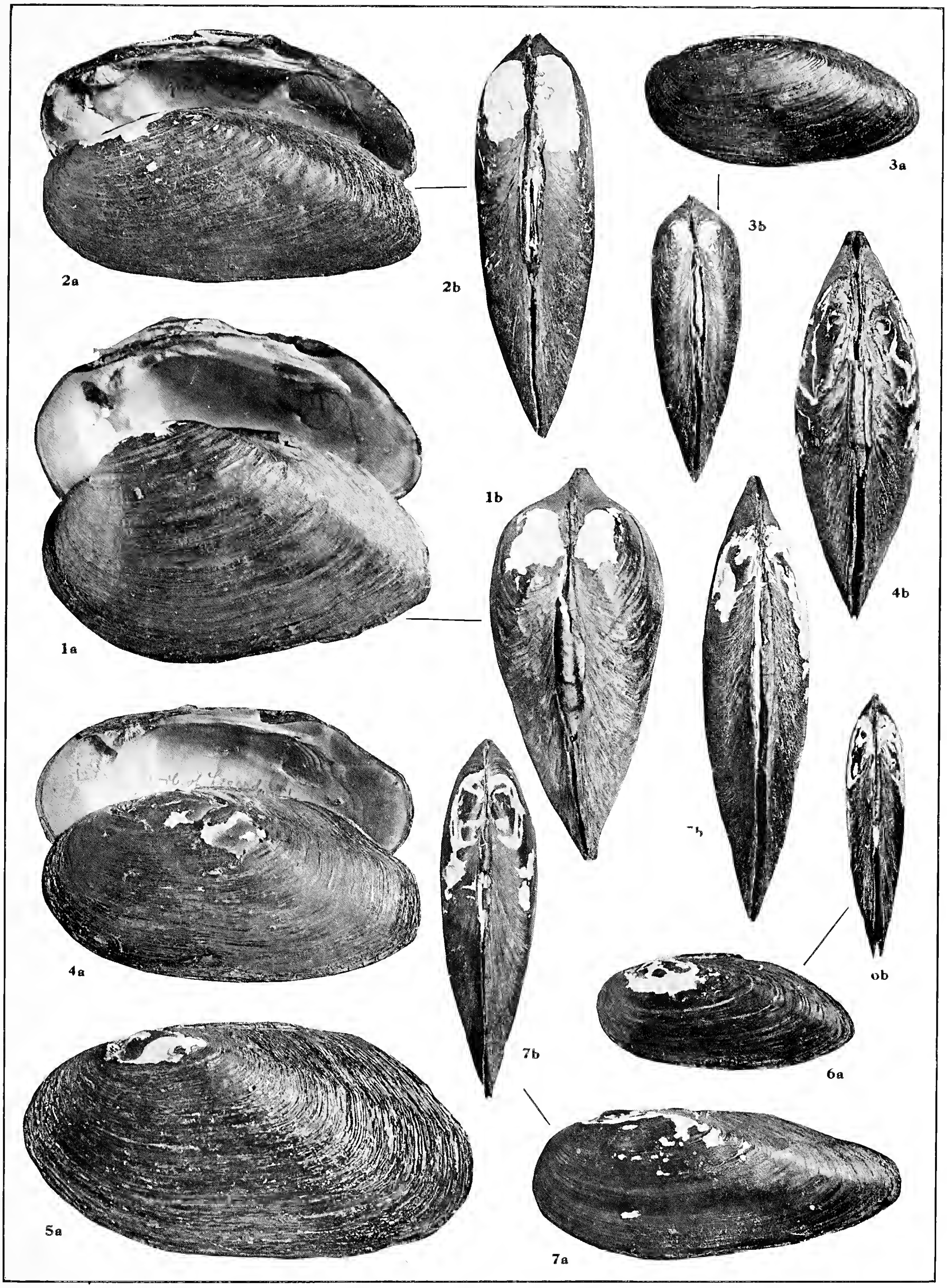
Fig. 3. *Elliptio dilatatus sterkii* Grier. Female, one of the types, which, however, is not much swollen, the diameter being only 32 percent of the length. From Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected July 12, 1910; C. M. Cat. No. 61.4628.

Fig. 4. *Elliptio violaceus* (Spengler). Normal specimen as found in smaller streams, from a small tributary of Lizard Creek, West Pēnn, Schuylkill Co., Pennsylvania, collected May 4, 1909; C. M. Cat. No. 61.4308.

Fig. 5. *Elliptio violaceus* (Spengler). Strongly compressed form with rough epidermis corresponding to the form called *jejunus* by Lea, from a mill-race of Crooked Creek, Tioga, Tioga Co., Pennsylvania, collected August 19, 1909; C. M. Cat. No. 61.4312.

Fig. 6. *Elliptio cupreus* (Rafinesque). Specimen of medium size from Great Tonoloway Creek, Thompson Township, Fulton Co., Pennsylvania, collected September 5, 1909; C. M. Cat. No. 61.4322.

Fig. 7. *Elliptio fisherianus* (Lea). Normal specimen of medium size from Choptank Mills, Kent Co., Delaware, collected by S. N. Rhoads, June, 1903; C. M. Cat. No. 61.4645.




*Elliptio.*

## EXPLANATION OF PLATE IX.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

Fig. 1. *Lasmigona* (*Platynaias*) *viridis* (Rafinesque). Gravid specimen, about full-grown, from Conneaut Outlet, Conneautlake, Crawford Co., Pennsylvania, collected May 14, 1908; C. M. Cat. No. 61.3297.

Fig. 2. *Lasmigona* (*Patynaias*) *viridis* (Rafinesque). Gravid specimen, young. This specimen shows the great similarity of young *L. viridis* to *L. subviridis* (compare Fig. 4). From Conneaut Outlet, Conneautlake, Crawford Co., Pennsylvania, collected August 7, 1908; C. M. Cat. No. 61.3679.

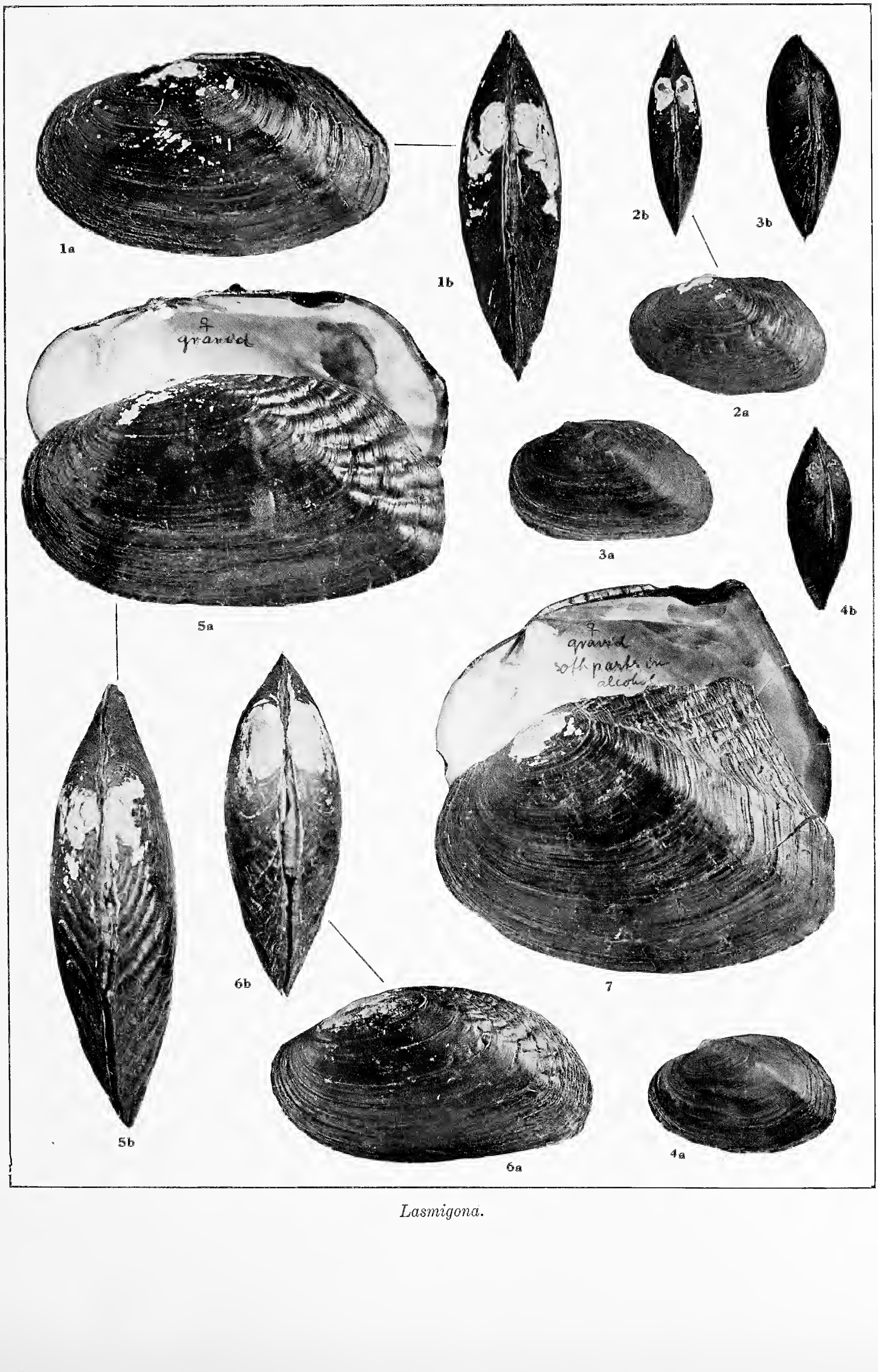
Fig. 3. *Lasmigona* (*Platynaias*) *subviridis* (Conrad). Gravid specimen, about full-grown, with exceptionally solid shell, from water heavily charged with lime. From Conococheague Creek, Greencastle, Franklin Co., Pennsylvania, collected September 6, 1909; C. M. Cat. No. 61.4222.

Fig. 4. *Lasmigona* (*Platynaias*) *subviridis* (Conrad). Gravid specimen of the normal, thin-shelled form, from Schuylkill Canal, Manayunk, Philadelphia Co., Pennsylvania, collected April 24, 1909; C. M. Cat. No. 61.4219.

Fig. 5. *Lasmigona* (*Lasmigona*) *costata* (Rafinesque). Gravid female of typical shape, from Shenango River, Shenango, Mercer Co., Pennsylvania, collected September 27, 1909; C. M. Cat. No. 61.4235.

Fig. 6. *Lasmigona* (*Lasmigona*) *costata eriganensis* Grier. Specimen from the set of types. From Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected May 22, 1909; C. M. Cat. No. 61.4223.

Fig. 7. *Lasmigona* (*Pterosyna*) *complanata* (Barnes). Gravid female, not quite full-grown, from Leboeuf Creek, Waterford, Erie Co., Pennsylvania, collected September 14, 1909; C. M. Cat. No. 61.4238.


1a
1b
2b
3b
2a
♀ gravid
3a
4b
5a
♀ gravid soft parts in alcohol
5b
6b
7
6a
4a

*Lasmigona.*

## EXPLANATION OF PLATE X.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

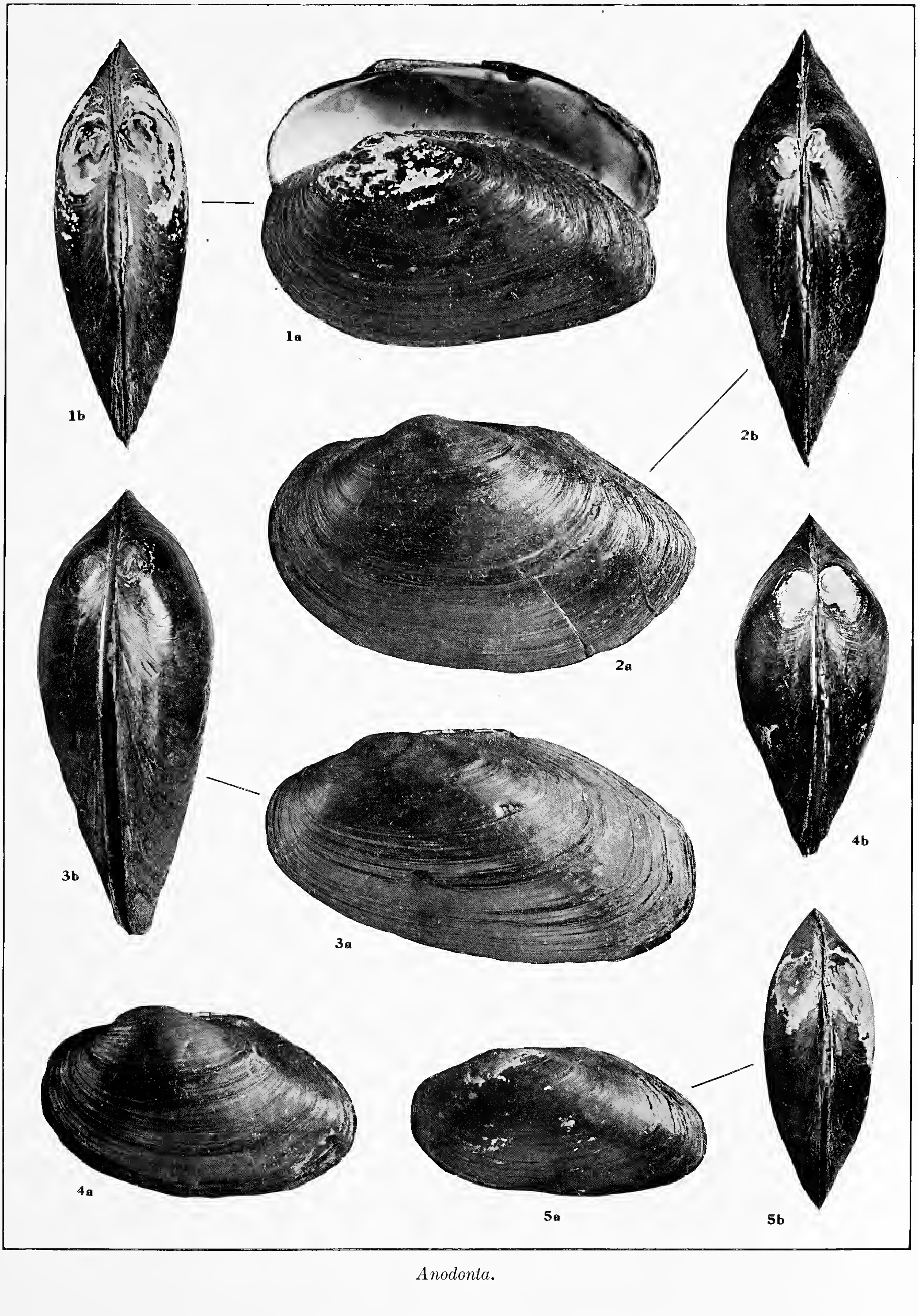
FIG. 1. *Anodonta grandis* Say. Normal creek-form, from Crooked Creek, Creekside, Indiana Co., Pennsylvania, collected May 27, 1908; C. M. Cat. No. 61.3649.

FIG. 2. *Anodonta grandis* Say. Gravid female of the pond-form *gigantea* (Lea), from pond at Harmarville, Allegheny Co., Pennsylvania, collected October 17, 1910; C. M. Cat. No. 61.4742.

FIG. 3. *Anodonta grandis footiana* (Lea). The form of the beach-pools, from Lake Erie, beach-pools of Presque Isle, Erie, Erie Co., Pennsylvania, collected June 2, 1908; C. M. Cat. No. 61.3651.

FIG. 4. *Anodonta grandis footiana* (Lea). Female of the form found in Presque Isle Bay, from Lake Erie, Presque Isle Bay (flats near west end), Erie, Erie Co., Pennsylvania, collected July 8, 1910; C. M. Cat. No. 61.4733.

FIG. 5. *Anodonta cataracta* Say. Creek-form, about half-grown, from White Clay Creek, Avondale, Chester Co., Pennsylvania, collected April 26, 1909; C. M. Cat. No. 61.4167.




*Anodonta.*

## EXPLANATION OF PLATE XI.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

FIG. 1. *Anodonta cataracta* Say. Gravid female of pond-form, of good size, from Pond near Paper Mill, Lockhaven, Clinton Co., Pennsylvania, collected August 24, 1909; C. M. Cat. No. 61.4173.

FIG. 2. *Anodonta implicata* Say. Normal specimen, rather swollen, from Timber Creek, Newbold, Gloucester Co., New Jersey, collected by C. H. Conner; C. M. Cat. No. 61.4442.

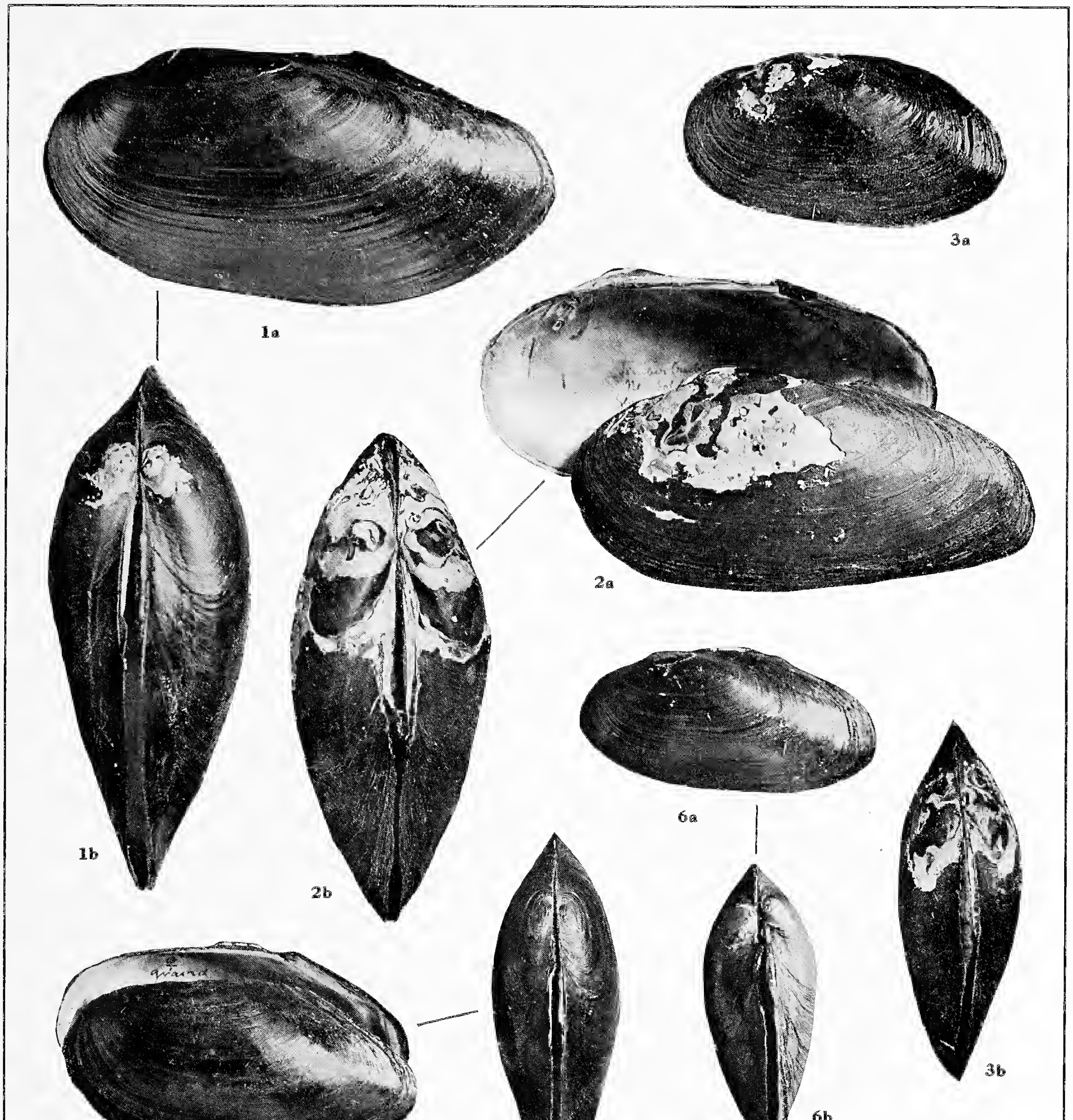
FIG. 3. *Anodonta implicata* Say. Young specimen of the river-form, from Delaware River, Yardley, Bucks Co., Pennsylvania, collected August 24, 1908; C. M. Cat. No. 61.3693.

FIG. 4. *Anodonta ohiënsis* Rafinesque. Gravid specimen, rather large, from Lake Erie, beach-pool of Presque Isle, Erie, Erie Co., Pennsylvania, collected June 2, 1908; C. M. Cat. No. 61.3291.

FIG. 5. *Anodontoides ferussacianus* (Lea). Specimen of medium size, from Little Shenango River, Greenville, Mercer Co., Pennsylvania, collected June 5, 1908; C. M. Cat. No. 61.3294.

FIG. 6. *Anodontoides ferussacianus buchanensis* (Lea). Typical specimen of medium size from Lake Erie, beach-pool of Presque Isle, Erie, Erie Co., Pennsylvania, collected June 2, 1908; C. M. Cat. No. 61.3295.

FIG. 7. *Alasmidonta (Alasmidonta) undulata* (Say). Gravid female of normal shape, from Conodoguinet Creek, Carlisle, Cumberland Co., Pennsylvania, collected August 13, 1910; C. M. Cat. No. 61.4660.




*Anodonta-Anadontoides-Alasmidonta.*

## EXPLANATION OF PLATE XII.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

Fig. 1. *Alasmidonta* (*Prolasmidonta*) *heterodon* (Lea). Adult male from the Schuylkill Canal, Manayunk, Philadelphia Co., Pennsylvania, collected April 24, 1909; C. M. Cat. No. 61.4250.

Fig. 2. *Alasmidonta* (*Prolasmidonta*) *heterodon* (Lea). Adult gravid female from the Schuylkill Canal, Manayunk, Philadelphia Co., Pennsylvania, collected April 24, 1909; C. M. Cat. No. 61.4250.

Fig. 3. *Alasmidonta* (*Decurambis*) *marginata* (Say). Adult gravid female from the Shenango River, Shenango, Mercer Co., Pennsylvania, collected September 27, 1909; C. M. Cat. No. 61.4270.

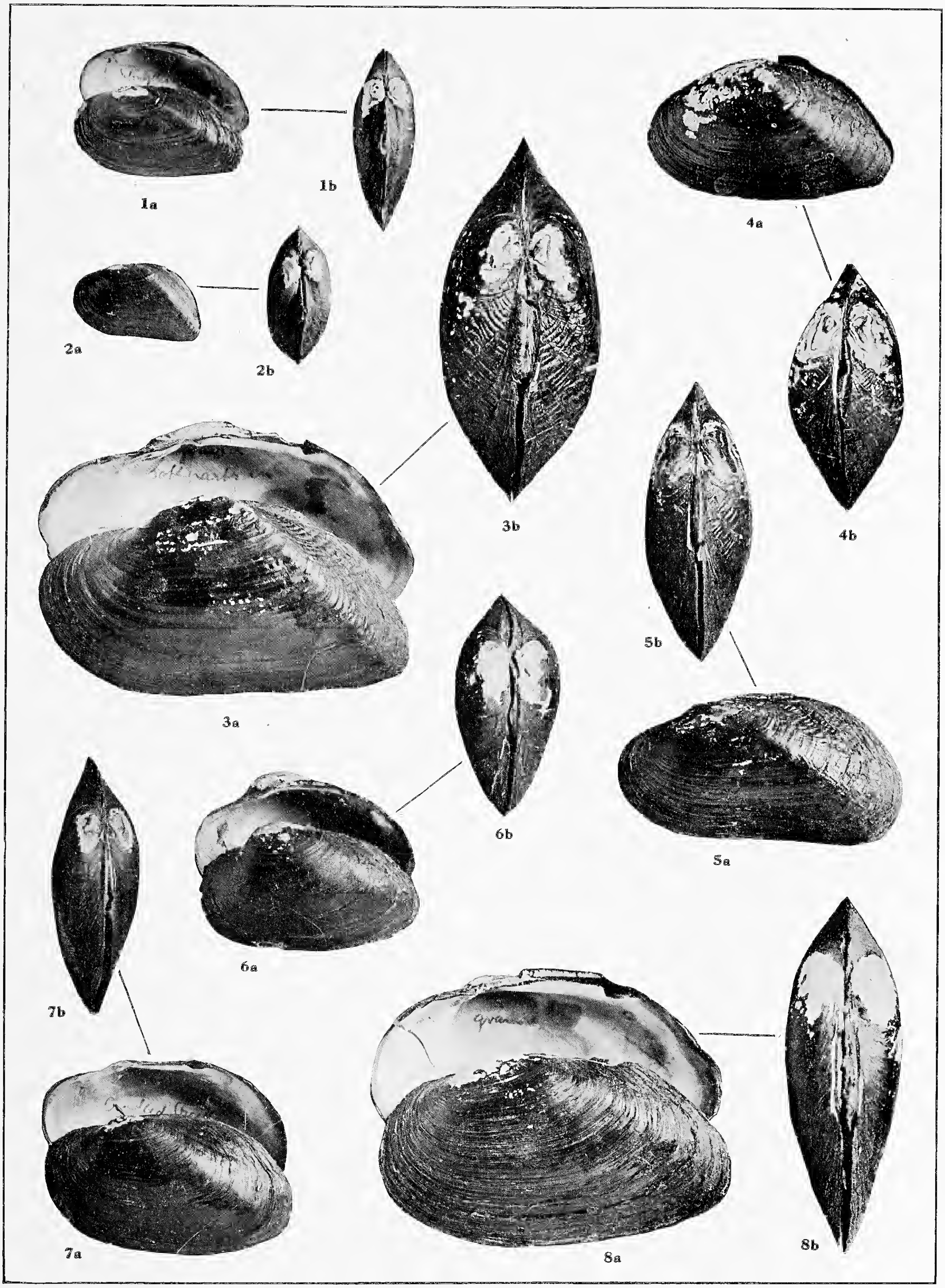
Fig. 4. *Alasmidonta* (*Decurambis*) *marginata susquehannæ* Ortmann. Male from the set of types, from the Susquehanna River, Selinsgrove, Snyder Co., Pennsylvania, collected August 14, 1910; C. M. Cat. No. 61.4679.

Fig. 5. *Alasmidonta* (*Decurambis*) *varicosa* (Lamarck). Adult female, from Princess Creek, Kunkletown, Monroe Co., Pennsylvania, collected June 14, 1910; C. M. Cat. No. 61.4671.

Fig. 6. *Strophitus undulatus* (Say). Specimen supposed to be this species, from Delaware River, Newbold, Gloucester Co., New Jersey, collected by C. H. Conner; C. M. Cat. No. 61.4135.

Fig. 7. *Strophitus edentulus* (Say). Half-grown male, from a mill-race of Crooked Creek, Tioga, Tioga Co., Pennsylvania, collected August 19, 1909; C. M. Cat. No. 61.4154.

Fig. 8. *Strophitus edentulus* (Say). Adult gravid female, from Conneaut Outlet, Conneautlake, Crawford Co., Pennsylvania, collected August 7, 1908; C. M. Cat. No. 61.3613.




*Alasmidonta-Strophitus.*

## EXPLANATION OF PLATE XIII.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

FIG. 1. *Ellipsaria fasciolaris* (Rafinesque). Gravid female from the Mahoning River, Mahoningtown, Lawrence Co., Pennsylvania, collected August 4, 1908; C. M. Cat. No. 61.3589.

FIG. 2. *Ellipsaria fasciolaris* (Rafinesque). Inside of female shell, showing the marsupial depressions, from the Shenango River, Pulaski, Lawrence Co., Pennsylvania, collected July 19, 1909; C. M. Cat. No. 61.4128.

FIG. 3. *Ellipsaria fasciolaris* (Rafinesque). Form of Lake Erie, female, from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected July 12, 1910; C. M. Cat. No. 61.4748.

FIG. 4. *Obliquaria reflexa* Rafinesque. Male, largest found in Pennsylvania, from the Ohio River, Industry, Beaver Co., Pennsylvania, collected October 5, 1909; C. M. Cat. No. 61.4423.

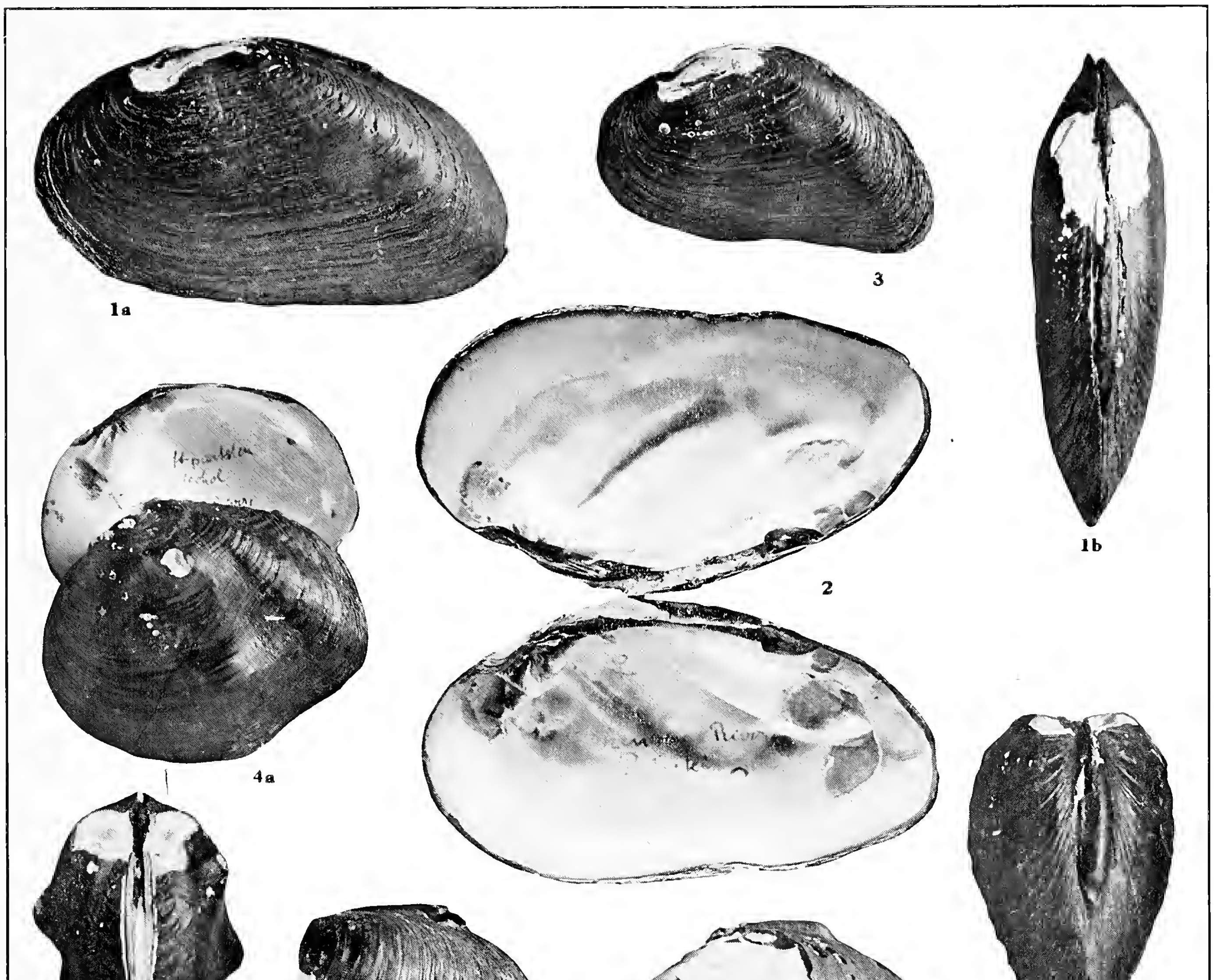
FIG. 5. *Cyprogenia stegaria* (Rafinesque). Largest specimen found in Pennsylvania in the Allegheny River, Godfrey, Armstrong Co., Pennsylvania, collected July 27, 1910; C. M. Cat. No. 61.4760.

FIG. 6. *Obovaria (Obovaria) retusa* (Lamarck). The only male (dead shell) found in Pennsylvania in the Ohio River, Industry, Beaver Co., Pennsylvania, collected October 22, 1908; C. M. Cat. No. 61.3556.

FIG. 7. *Obovaria (Obovaria) retusa* (Lamarck). Gravid female, the only living specimen found in Pennsylvania, in the Ohio River, Industry, Beaver Co., Pennsylvania, collected August 29, 1908; C. M. Cat. No. 61.3555.

FIG. 8. *Obovaria (Pseudoön) olivaria* (Rafinesque). Male from the Ohio River, Portland, Meigs Co., Ohio, collected September 22, 1910; C. M. Cat. No. 61.4776.

FIG. 9. *Obovaria (Pseudoön) olivaria* (Rafinesque). Female from the Ohio River, Industry, Beaver Co., Pennsylvania, collected August 29, 1908; C. M. Cat. No. 61.3561.




*Ellipsaria-Obliquaria-Cyprogenia-Obovaria.*

## EXPLANATION OF PLATE XIV.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

FIG. 1. *Obovaria* (*Obovaria*) *subrotunda* (Rafinesque). Probably male according to shape, diameter 68 percent of length, from the Monongahela River, Charleroi, Washington Co., Pennsylvania, collected by G. A. Ehrmann; C. M. Cat. No. 61.2840.

FIG. 2. *Obovaria* (*Obovaria*) *subrotunda* (Rafinesque). Probably a female, judging from the shape; diameter 62 percent of length, from the Monongahela River, Charleroi, Washington Co., Pennsylvania, collected by G. A. Ehrmann; C. M. Cat. No. 61.2840.

FIG. 3. *Obovaria* (*Obovaria*) *subrotunda levigata* (Rafinesque). Male, diameter 50 percent of length, from the Shenango River, Clarksville, Mercer Co., Pennsylvania collected September 21, 1908; C. M. Cat. No. 61.3558.

FIG. 4. *Obovaria* (*Obovaria*) *subrotunda levigata* (Rafinesque). Female, diameter 52 percent of length, from the Shenango River, Clarksville, Mercer Co., Pennsylvania, collected September 21, 1908; C. M. Cat. No. 61.3558.

FIG. 5. *Actinonaias ligamentina* (Lamarck). Male of medium size from the Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected October 4, 1907; C. M. Cat. No. 61.3108.

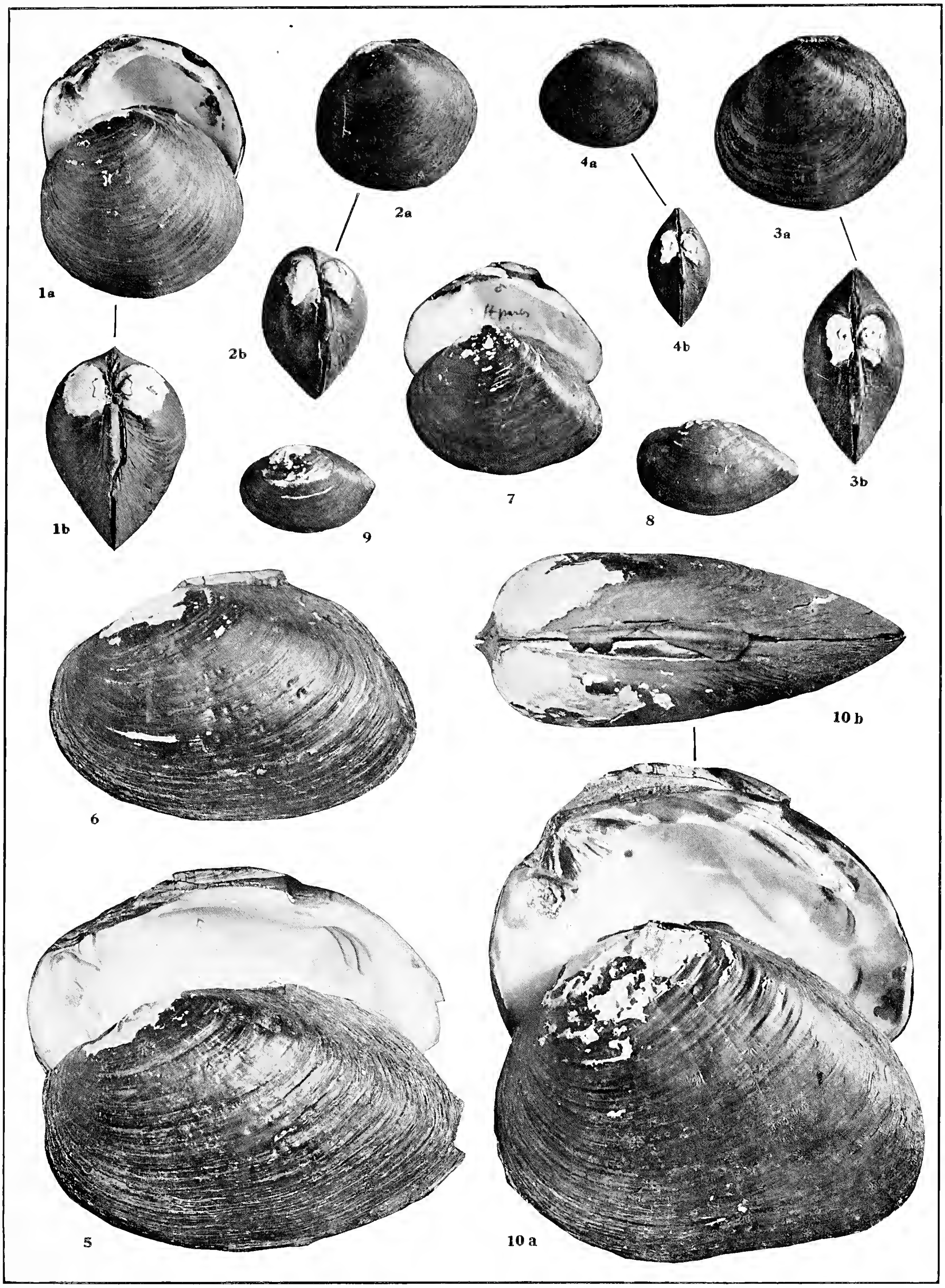
FIG. 6. *Actinonaias ligamentina* (Lamarck). Gravid female of medium size from the Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected October 4, 1907; C. M. Cat. No. 61.3108.

FIG. 7. *Amygdalonaias truncata* (Rafinesque). Male from the Ohio River, Industry, Beaver Co., Pennsylvania, collected September 8, 1908; C. M. Cat. No. 61.3569.

FIG. 8. *Amygdalonaias donaciformis* (Lea). Male from the Missouri River, St. Joseph, Buchanan Co., Missouri, collected by W. I. Utterback, November 1, 1913; C. M. Cat. No. 61.6887.

FIG. 9. *Amygdalonaias donaciformis* (Lea). Female from the Missouri River, St. Joseph, Buchanan Co., Missouri, collected by W. I. Utterback, November 1, 1913; C. M. Cat. No. 61.6887.

FIG. 10. *Plagiola lineolata* (Rafinesque). Adult male from the Ohio River, Cook's Ferry, Beaver Co., Pennsylvania, collected September 12, 1908; C. M. Cat. No. 61.3565.




*Obovaria-Actinonaias-Amygdalonaias-Plagiola.*

## EXPLANATION OF PLATE XV.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

FIG. 1. *Plagiola lineolata* (Rafinesque). Half-grown male from the Ohio River, Cook's Ferry, Beaver Co., Pennsylvania, collected September 10, 1908; C. M. Cat. No. 61.3565.

FIG. 2. *Plagiola lineolata* (Rafinesque). Adult gravid female from the Ohio River, Cook's Ferry, Beaver Co., Pennsylvania, collected September 12, 1908; C. M. Cat. No. 61.3565.

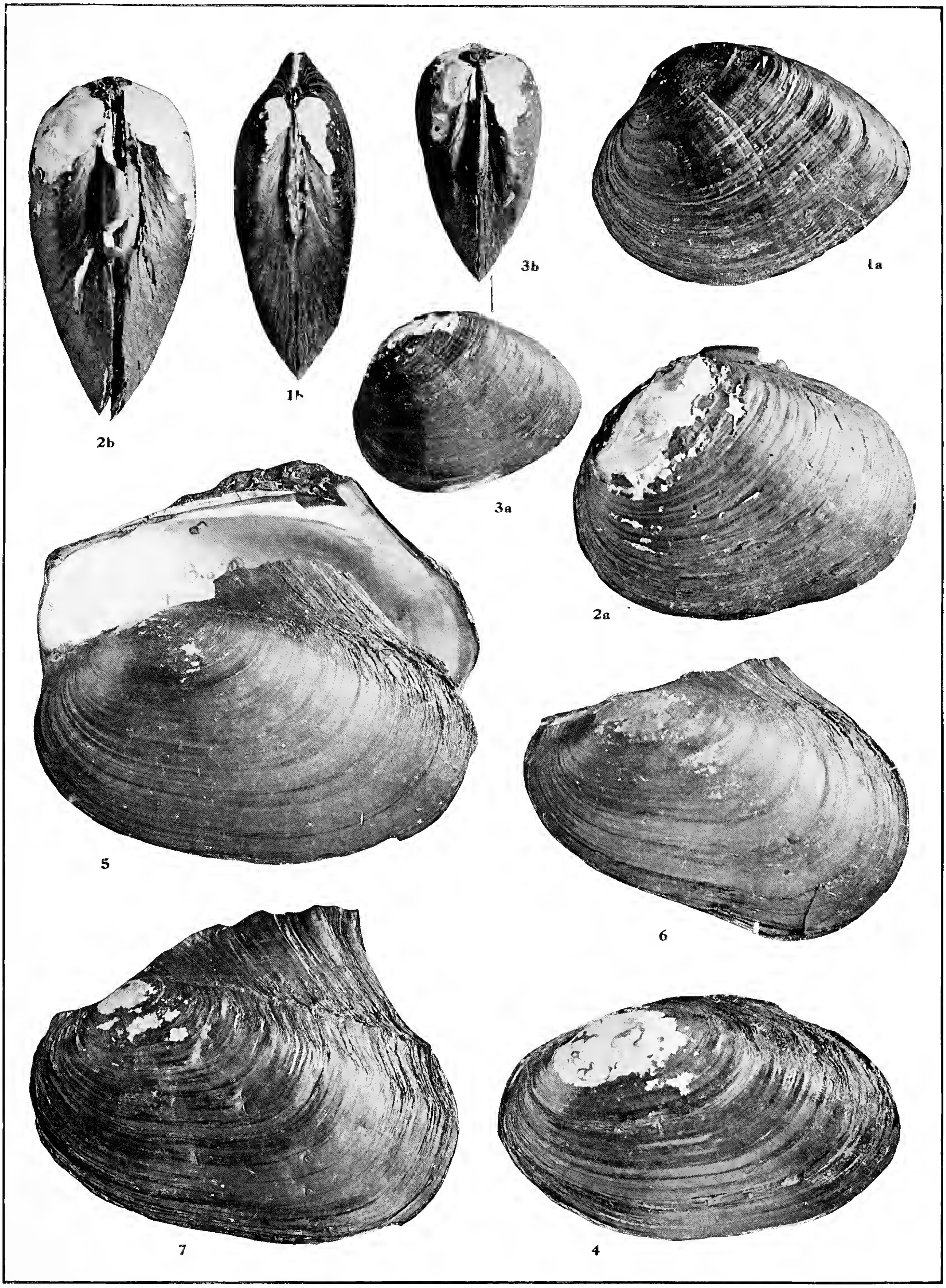
FIG. 3. *Plagiola lineolata* (Rafinesque). Half-grown gravid female from the Ohio River, Cook's Ferry, Beaver Co., Pennsylvania, collected September 10, 1908; C. M. Cat. No. 61.3565.

FIG. 4. *Paraptera fragilis* (Rafinesque). Male of Ohio-form from the Ohio River, Industry, Beaver Co., Pennsylvania, collected September 23, 1908; C. M. Cat. No. 61.3549.

FIG. 5. *Paraptera fragilis* (Rafinesque). Male of Lake Erie-form from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected July 12, 1910; C. M. Cat. No. 61.4807.

FIG. 6. *Paraptera fragilis* (Rafinesque). Female of Lake Erie-form from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected July 12, 1910; C. M. Cat. No. 61.4807.

FIG. 7. *Proptera alata* (Say). Male of Ohio-form, about half-grown, from Ohio River, Industry, Beaver Co., Pennsylvania, collected August 30, 1909; C. M. Cat. No. 61.4108.




*Plagiola-Paraptera-Proptera.*

## EXPLANATION OF PLATE XVI.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

Fig. 1. *Proptera alata* (Say). Gravid female of Ohio-form, half-grown, from the Ohio River, Industry, Beaver Co., Pennsylvania, collected August 30, 1909; C. M. Cat. No. 61.4108.

Fig. 2. *Proptera alata* (Say). Gravid female of Lake Erie-form, nearly adult, from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected May 21, 1909; C. M. Cat. No. 61.4102.

Fig. 3. *Toxolasma parvum* (Barnes). Gravid female from Conneaut Outlet, Conneautlake, Crawford Co., Pennsylvania, collected June 17, 1909; C. M. Cat. No. 61.4101.

Fig. 4. *Eurynia* (*Micromya*) *fabalis* (Lea). Male, according to shape, from Allegheny River, Walnut Bend, Venango Co., Pennsylvania, collected September 6, 1908; C. M. Cat. No. 61.3376.

Fig. 5. *Eurynia* (*Micromya*) *fabalis* (Lea). Female, judging from the shape, from the Allegheny River, Walnut Bend, Venango Co., Pennsylvania, collected September 6, 1908; C. M. Cat. No. 61.3376.

Fig. 6. *Eurynia* (*Micromya*) *iris* (Lea). Male from Slipperyrock Creek, Wurtemberg, Lawrence Co., Pennsylvania, collected June 23, 1910; C. M. Cat. No. 61.4827.

Fig. 7. *Eurynia* (*Micromya*) *iris* (Lea). Gravid female from Little Beaver Creek, Enon Valley, Lawrence Co., Pennsylvania, collected May 11, 1907; C. M. Cat. No. 61.2159.

Fig. 8. *Eurynia* (*Micromya*) *iris novi-eboraci* (Lea). Male from Conneaut Creek, West Springfield, Erie Co., Pennsylvania, collected May 23, 1909; C. M. Cat. No. 61.4091.

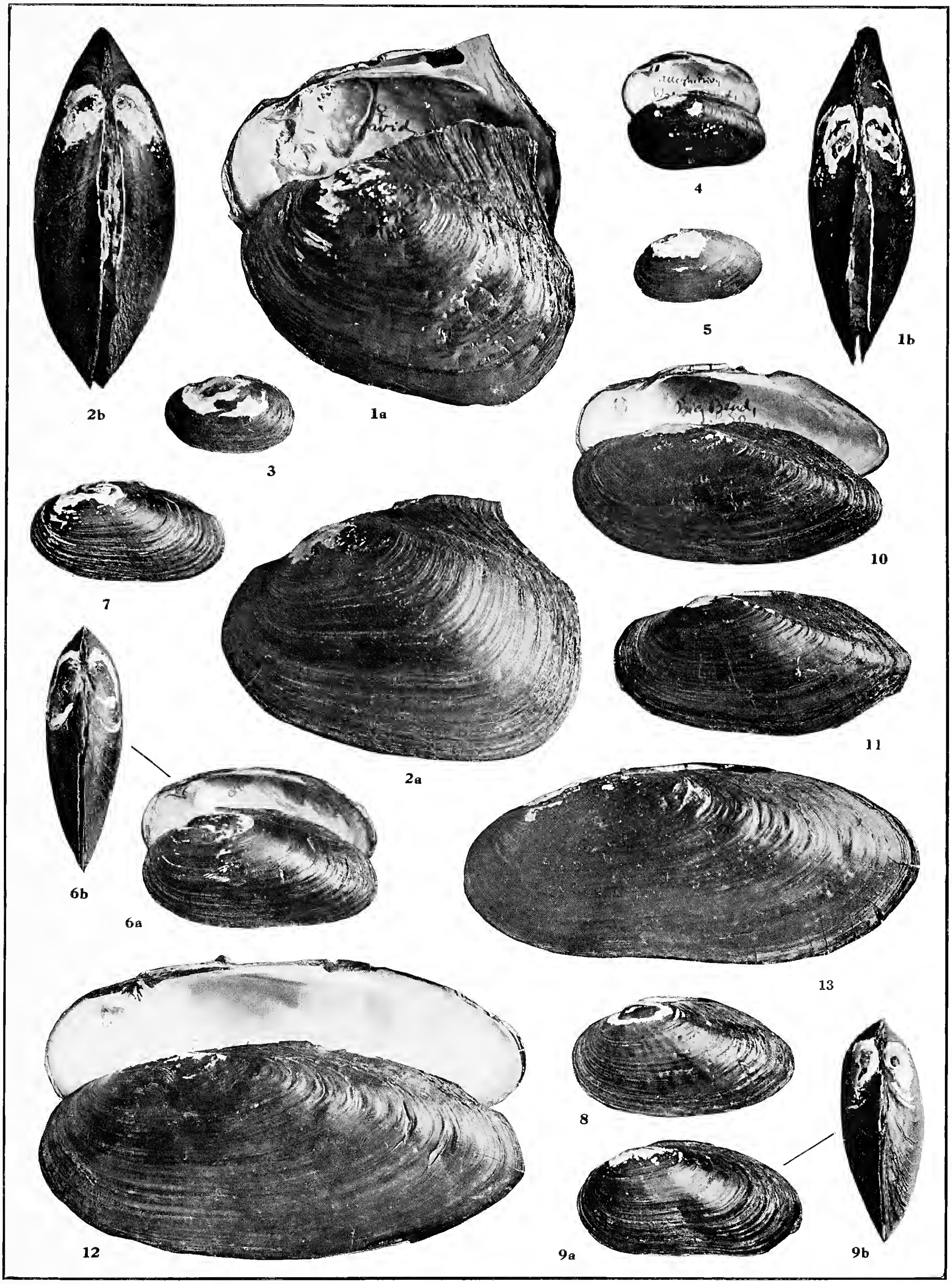
Fig. 9. *Eurynia* (*Micromya*) *iris novi-eboraci* (Lea). Female, judging from the shape, from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected July 7, 1910; C. M. Cat. No. 61.4831.

Fig. 10. *Eurynia* (*Eurynia*) *nasuta* (Say). Male from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected July 8, 1910; C. M. Cat. No. 61.4840.

Fig. 11. *Eurynia* (*Eurynia*) *nasuta* (Say). Female from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected July 12, 1910; C. M. Cat. No. 61.4840.

Fig. 12. *Eurynia* (*Eurynia*) *recta* (Lamarck). Male of medium size from French Creek, Meadville, Crawford Co., Pennsylvania, collected September 1, 1908; C. M. Cat. No. 61.3512.

Fig. 13. *Eurynia* (*Eurynia*) *recta* (Lamarck). Gravid female of medium size from French Creek, Meadville, Crawford Co., Pennsylvania, collected September 1, 1908; C. M. Cat. No. 61.3512.




*Proptera-Toxolasma-Eurynia.*

## EXPLANATION OF PLATE XVII.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

FIG. 1. *Lampsilis luteola* (Lamarck). Male from Mahoning River, Edinburg, Lawrence Co., Pennsylvania, collected September 15, 1908; C. M. Cat. No. 61.3466.

FIG. 2. *Lampsilis luteola* (Lamarck). Gravid female from Mahoning River, Edinburg, Lawrence Co., Pennsylvania, collected September 15, 1908; C. M. Cat. No. 61.3466.

FIG. 3. *Lampsilis luteola rosacea* (DeKay). Male, deep water form, with very regular growth-rests, from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, taken at a depth of fourteen to sixteen feet, collected July 22, 1909; C. M. Cat. No. 61.4033.

FIG. 4. *Lampsilis luteola rosacea* (DeKay). Male, form of the open shore, from Lake Erie, outer shore of Presque Isle, Erie, Erie Co., Pennsylvania, from a depth of ten feet, collected July 11, 1910; C. M. Cat. No. 61.4862.

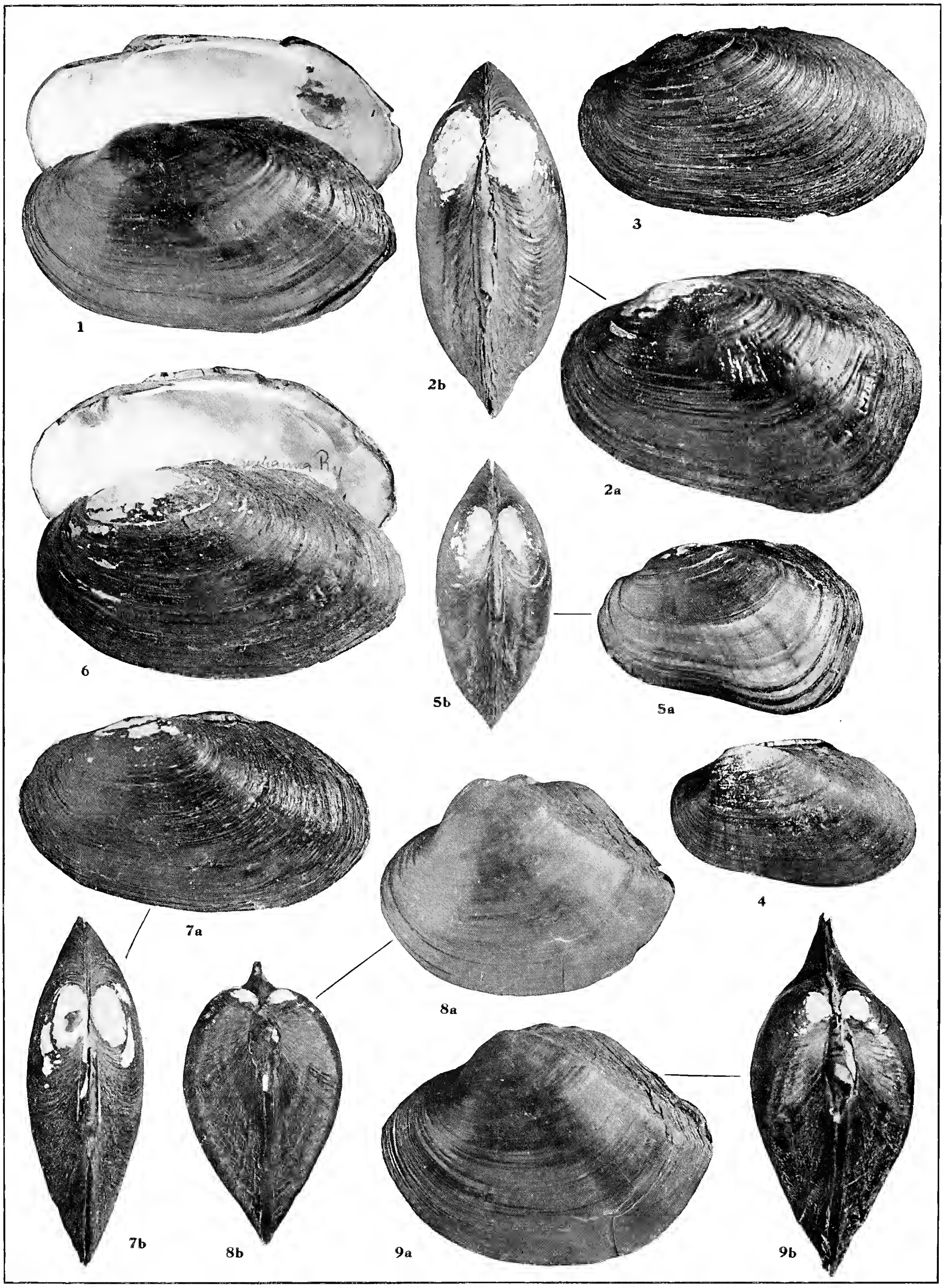
FIG. 5. *Lampsilis luteola rosacea* (DeKay). Female, normal form of the bay, from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, taken from shallow water, collected July 9, 1910; C. M. Cat. No. 61.4861.

FIG. 6. *Lampsilis radiata* (Gmelin). Male from North Branch Susquehanna River, Tunkhannock, Wyoming Co., Pennsylvania, collected August 21, 1909; C. M. Cat. No. 61.4054.

FIG. 7. *Lampsilis radiata* (Gmelin). Gravid female from North Branch of the Susquehanna River, Tunkhannock, Wyoming Co., Pennsylvania, collected August 21, 1909; C. M. Cat. No. 61.4054.

FIG. 8. *Lampsilis ovata* (Say). Young specimen, probably male, from French Creek, Cambridge Springs, Crawford Co., Pennsylvania, collected September 13, 1909; C. M. Cat. No. 61.4010.

FIG. 9. *Lampsilis ovata* (Say). Young specimen, probably female, but female shape barely indicated, from French Creek, Cambridge Springs, Crawford Co., Pennsylvania, collected September 13, 1909; C. M. Cat. No. 61.4010.




*Lampsilis.*

## EXPLANATION OF PLATE XVIII.

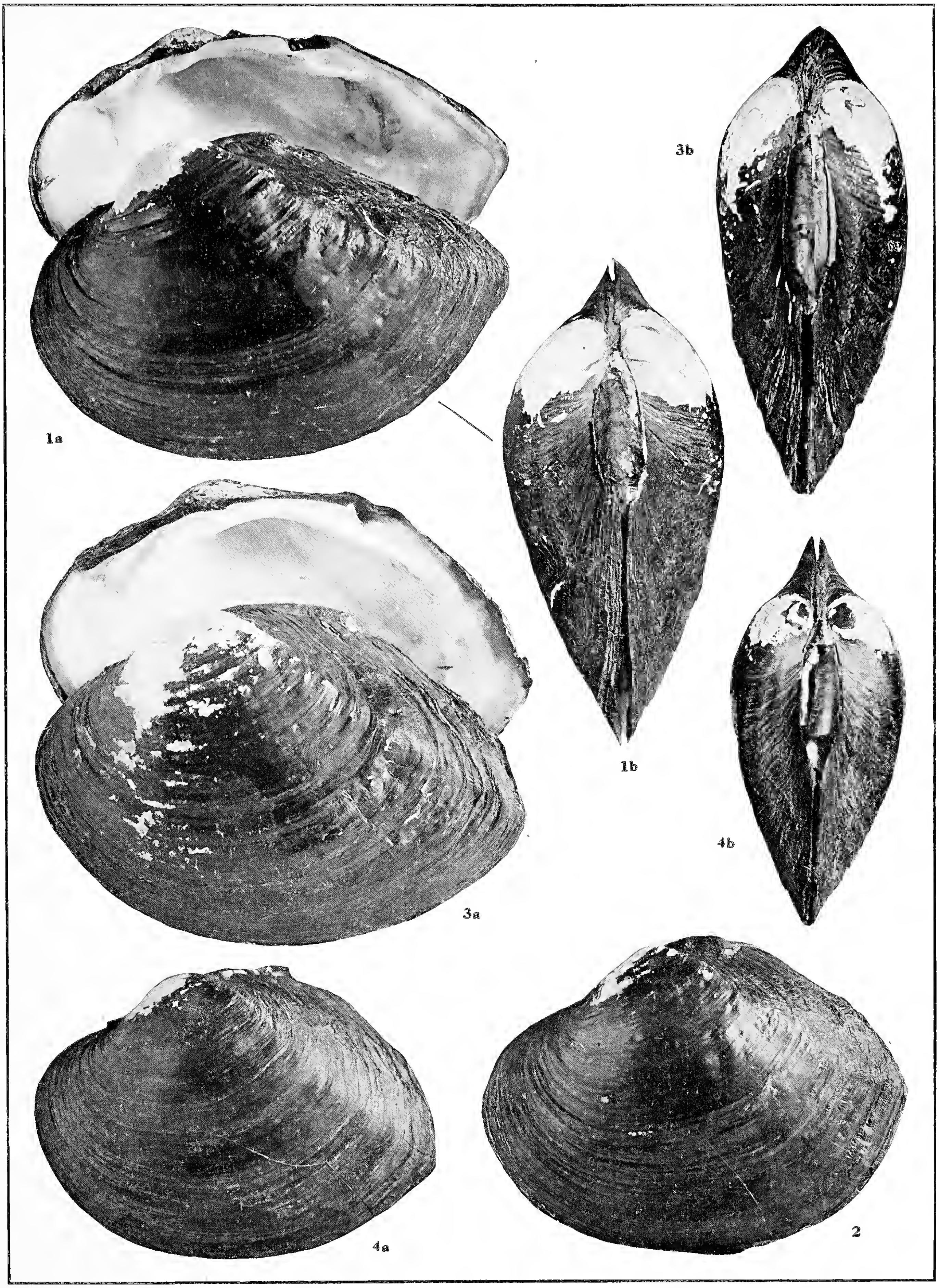
All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

Fig. 1. *Lampsilis ovata* (Say). Normal adult male from the Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected August 30, 1907; C. M. Cat. No. 61.2994.

Fig. 2. *Lampsilis ovata* (Say). Normal gravid female from the Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected August 30, 1907; C. M. Cat. No. 61.2994.

Fig. 3. *Lampsilis ovata* (Say). Male, strongly inclining in shape toward the var. *ventricosa*, from the Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected July 5, 1909; C. M. Cat. No. 61.4007.

Fig. 4. *Lampsilis ovata ventricosa* (Barnes). Male, slightly inclining toward the normal *ovata*, from French Creek, Cambridge Springs, Crawford Co., Pennsylvania, collected September 13, 1909; C. M. Cat. No. 61.3996.




*Lampsilis.*

## EXPLANATION OF PLATE XIX.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

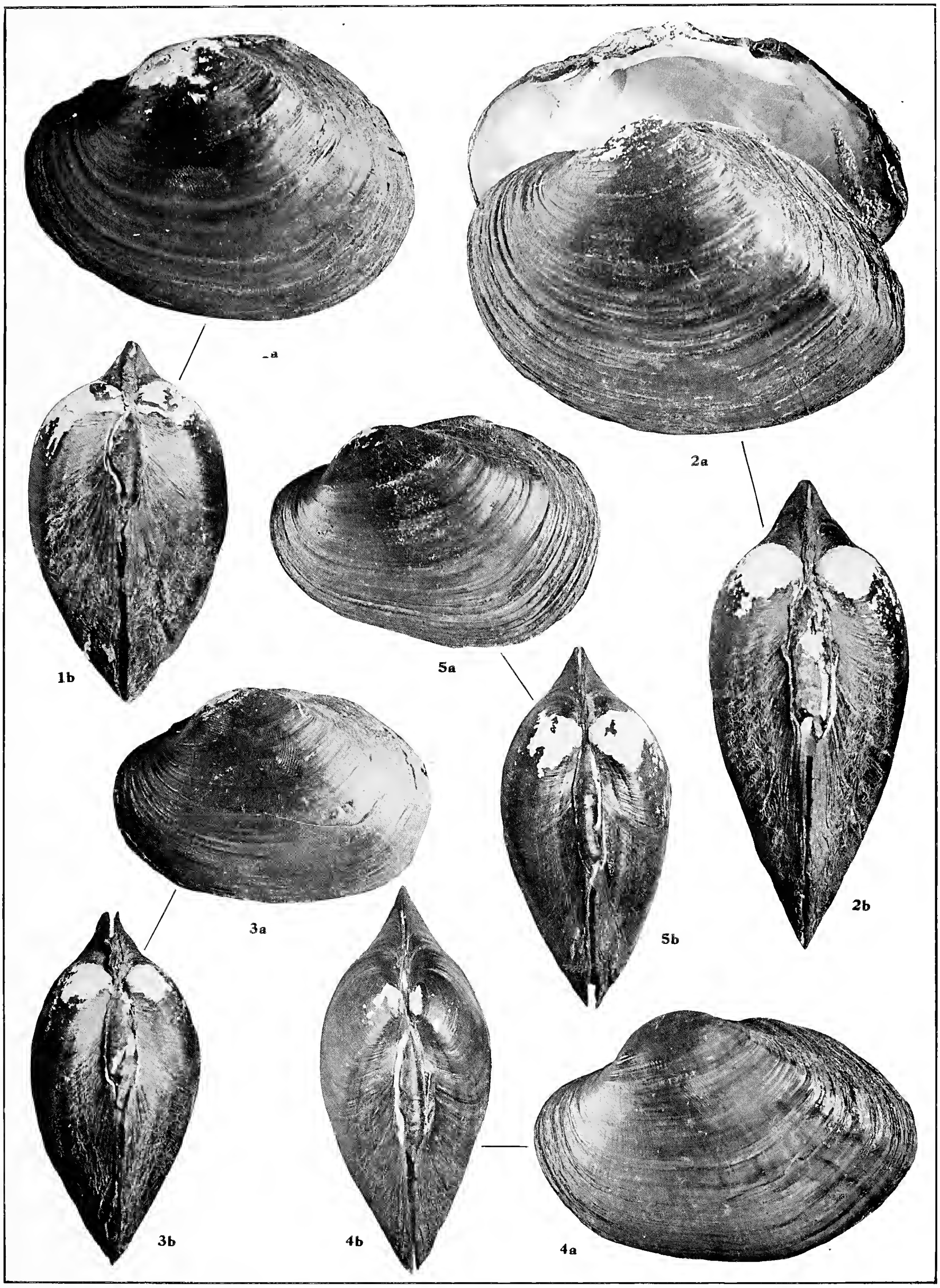
Fig. 1. *Lampsilis ovata ventricosa* (Barnes). Quite normal gravid female from French Creek, Cambridge Springs, Crawford Co., Pennsylvania, collected September 13, 1909; C. M. Cat. No. 61.3996.

Fig. 2. *Lampsilis ovata ventricosa* (Barnes). Typical male from the Shenango River, Clarksville, Mercer Co., Pennsylvania, collected September 21, 1908; C. M. Cat. No. 61.3404.

Fig. 3. *Lampsilis ovata ventricosa* (Barnes). Typical half-grown gravid female from the Shenango River, Clarksville, Mercer Co., Pennsylvania, collected September 21, 1908; C. M. Cat. No. 61.3404.

Fig. 4. *Lampsilis ovata canadensis* (Lea). Male from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected May 21, 1909; C. M. Cat. No. 61.3982.

Fig. 5. *Lampsilis ovata canadensis* (Lea). Female from Lake Erie, Presque Isle Bay, Erie, Erie Co., Pennsylvania, collected May 22, 1909; C. M. Cat. No. 61.3982.




*Lampsilis.*

## EXPLANATION OF PLATE XX.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

Fig. 1. *Lampsilis fasciola* Rafinesque. Male from Shenango River, Shenango, Mercer Co., Pennsylvania, collected September 27, 1909; C. M. Cat. No. 61.4099.

Fig. 2. *Lampsilis fasciola* Rafinesque. Gravid female from the Allegheny River, Warren, Warren Co., Pennsylvania, collected September 15, 1909; C. M. Cat. No. 61.4019.

Fig. 3. *Lampsilis cariosa* (Say). Very large male from the Chemung River, South Waverly, Bradford Co., Pennsylvania, collected August 20, 1909; C. M. Cat. No. 61.4003.

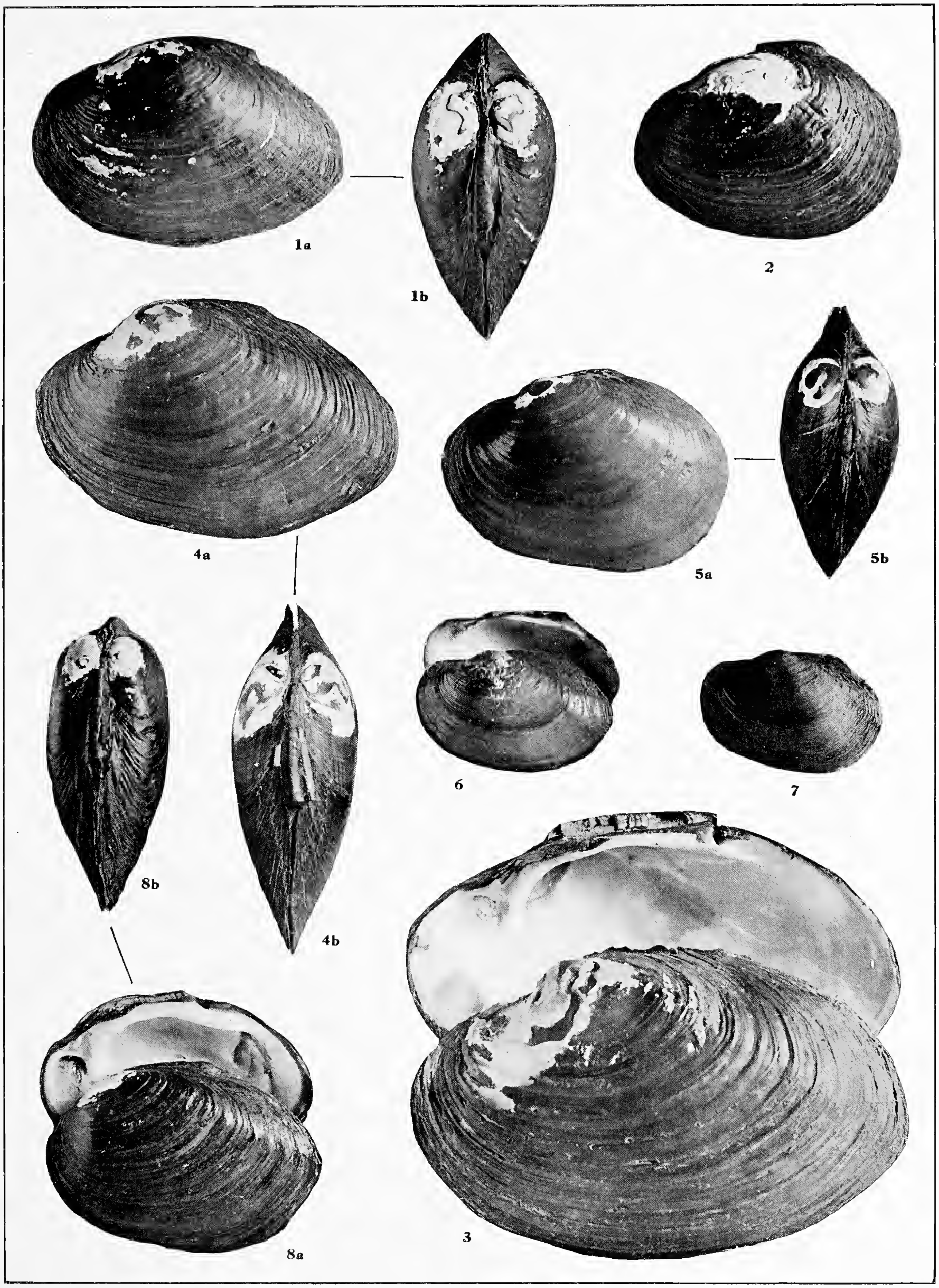
Fig. 4. *Lampsilis cariosa* (Say). Male of normal size from the Susquehanna River, Duncannon, Perry Co., Pennsylvania, collected August 14, 1908; C. M. Cat. No. 61.3414.

Fig. 5. *Lampsilis cariosa* (Say). Gravid female from the Susquehanna River, Duncannon, Perry Co., Pennsylvania, collected August 14, 1908; C. M. Cat. No. 61.3414.

Fig. 6. *Lampsilis ochracea* (Say). Probably male, judging from the shape, hardly half-grown, from an unknown locality in the Hartman collection; C. M. Cat. No. 61.4437.

Fig. 7. *Lampsilis ochracea* (Lea). Probably a female, judging from the shape, hardly half-grown, from the Delaware River, Newbold, Gloucester Co., New Jersey, collected by C. H. Conner; C. M. Cat. No. 61.4012.

Fig. 8. *Lampsilis orbiculata* (Hildreth). Half-grown male from the Allegheny River, Godfrey, Armstrong Co., Pennsylvania, collected October 8, 1908; C. M. Cat. No. 61.3504.




*Lampsilis.*

## EXPLANATION OF PLATE XXI.

All figures are three-fourths natural size. *a*, lateral view; *b*, dorsal view.

Fig. 1. *Lampsilis orbiculata* (Hildreth). Half-grown female from the Allegheny River, Godfrey, Armstrong Co., Pennsylvania, collected October 8, 1908; C. M. Cat. No. 61.3504.

Fig. 2. *Lampsilis orbiculata* (Hildreth). Very large and much swollen gravid female from the Ohio River, Industry, Beaver Co., Pennsylvania, collected September 23, 1908; C. M. Cat. No. 61.3500.

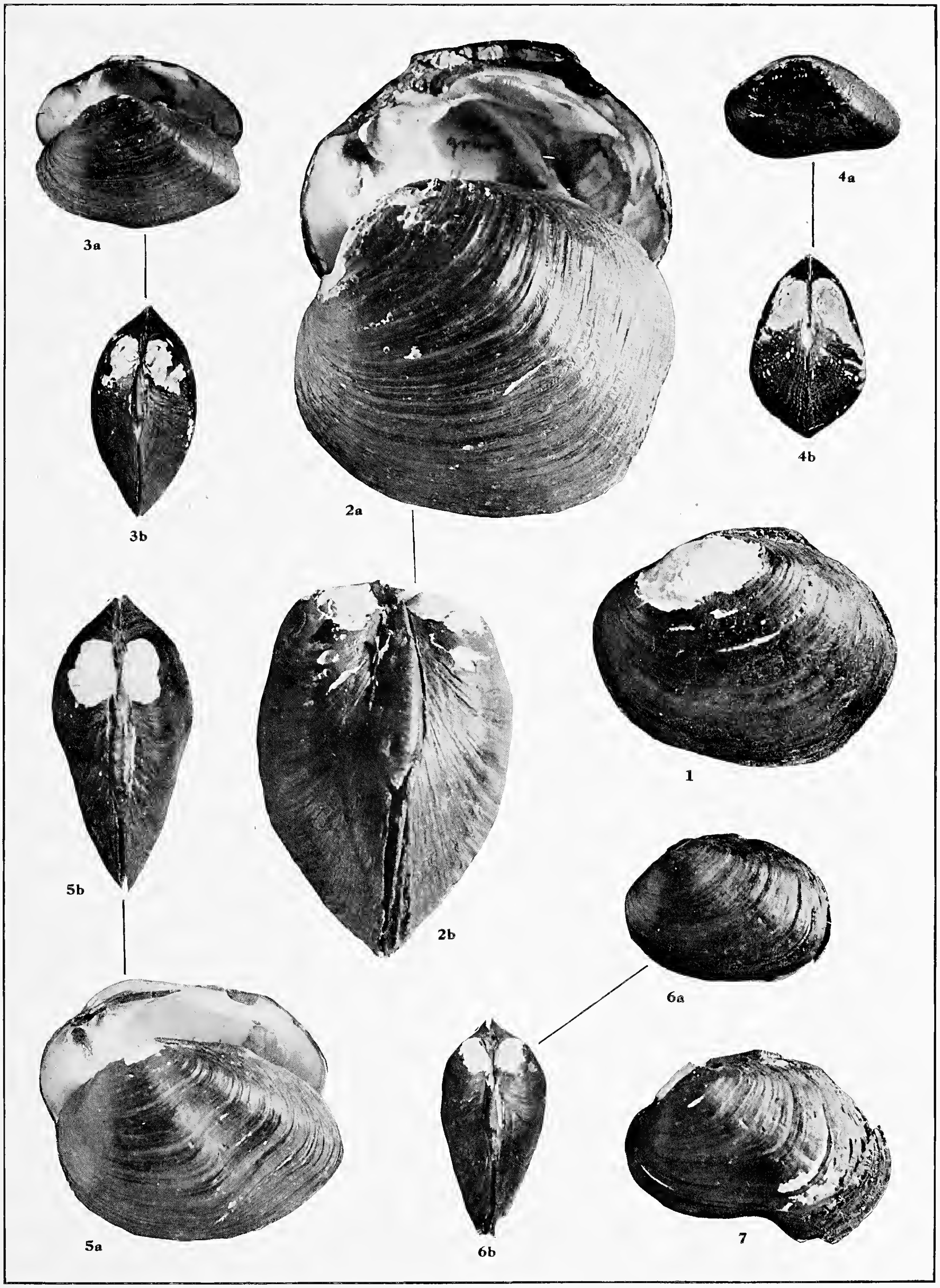
Fig. 3. *Truncilla triquetra* Rafinesque. Male from the Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected September 27, 1907; C. M. Cat. No. 61.2985.

Fig. 4. *Truncilla triquetra* Rafinesque. Gravid female from the Allegheny River, Kelly, Armstrong Co., Pennsylvania, collected September 27, 1907; C. M. Cat. No. 61.2985.

Fig. 5. *Truncilla rangiana* (Lea). Adult male from French Creek, Cochranton, Crawford Co., Pennsylvania collected September 2, 1908; C. M. Cat. No. 61.3363.

Fig. 6. *Truncilla rangiana* (Lea). Half-grown female from French Creek, Cochranton, Crawford Co., Pennsylvania, collected September 2, 1908; C. M. Cat. No. 61.3363.

Fig. 7. *Truncilla rangiana* (Lea). Fully adult gravid female from French Creek, Cochranton, Crawford Co., Pennsylvania, collected September 2, 1908; C. M. Cat. No. 61.3363.




*Lampsilis-Truncilla.*

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# MEMOIRS

OF THE

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VOL. VIII. NO. 2.

W. J. HOLLAND, EDITOR.



## FOSSIL PLANTS FROM THE BEDS OF VOLCANIC ASH NEAR MISSOULA, WESTERN MONTANA

By O. E. JENNINGS

PITTSBURGH.
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MEMOIRS

OF THE

CARNEGIE MUSEUM.

VOL. VIII. NO. 2.

# FOSSIL PLANTS FROM THE BEDS OF VOLCANIC ASH NEAR MISSOULA, WESTERN MONTANA.

BY O. E. JENNINGS.

(PLATES XXII–XXXIII)



## INTRODUCTORY.

This paper deals with some fossil plants obtained by Mr. Earl Douglass from the beds of volcanic ash in the vicinity of Missoula, Montana, and with a smaller collection made by him near Winston, Montana. The specimens are now in the Carnegie Museum.

The fossils from near Missoula were collected by Mr. Douglass from two places. One of these places is termed on the labels "Locality 165" and is stated to be about one and one-half miles north of Missoula, the collections having been made September 26–30, 1903. These beds are noted as being "Several hundred feet thick and are composed of volcanic ash, sandstone, conglomerate, etc. There are several seams of coal." Another label from the same place says: "In beds of volcanic ash. Coal above and below." The other station from near Missoula, and from which the better part of the material came, is evidently near "Locality 165" and is called on the labels "Locality 196." The collection from Winston was made on September 23, 1902, on the north side of Beaver Creek, northeast of Winston, Montana. This latter collection is a small one, containing but two or possibly three species.

The Missoula collections, with which this paper is mainly concerned, were

taken by Douglass from beds which he believed to be of Oligocene age.[1] He states that they "appear in the main to represent the Titanotherium and Oreodon beds of South Dakota." This horizon, as understood by most American paleontologists, includes approximately the lower half of the White River formation.[2] The fossil plants in these deposits consist of impressions of leaves and of leafy twigs, there being also a few impressions of fruits and leafless twigs. The Missoula specimens are in a very light colored, grayish-white, soft and friable rock, consisting of a fine-grained volcanic ash, which was evidently more or less stratified and laminated.[3-4] It is generally believed that the dust was wind-borne and that it was mainly deposited in freshwater lakes or other shallow basins. Douglass states that "It does not appear that the water was as a rule very deep. There are undoubtedly not only lake but marsh and river deposits. . . . We find nearly everywhere evidences of shallow water, such as ripple marks, bird tracks, plant remains, shallow water mollusca, etc." Rowe[5] also states his belief that the ash fell in freshwater lakes.

The Missoula specimens mostly preserve in considerable detail even the finer venation of the leaf surfaces, and in a number of instances the outline of the whole leaf is plainly evident. The Winston specimens are, however, in a harder, light gray rock, which has slickenside surfaces developed at various angles and directions and presents every appearance of having once been a slumping mass of very fine-grained mud. In this material the fossils are unsatisfactory, the hardness of the rock and its irregularity of fracture resulting in fragmentary specimens.

I have undertaken the study of these various collections more as a student of modern systematic botany and ecology than as a paleobotanist, and it is barely possible that my conclusions may in some instances differ from what might have been those of a paleobotanist, trained as a stratigrapher. However, no sharp line of distinction can now be drawn between the work of a paleobotanist on the one hand and that of the student of modern botany and ecology on the other, and it is plainly evident that each of these fields of study may yet receive many valuable and enlightening contributions from the other.

In the preparation of the illustrations accompanying this article I have had the able assistance of my wife, Grace K. Jennings, and to her is due quite largely

[1] Douglass, Earl. New Vertebrates from the Montana Territory. Annals Carnegie Museum, II, 1903, 145–199.

[2] Willis, Bailey. Index to the Stratigraphy of North America. U. S. Geol. Surv., Prof. Paper LXXI, 1912, p. 770.

[3] Rowe, J. P. Some Volcanic Ash Beds of Montana. Univ. Montana Bull., XVII, 1903.

[4] *Op. cit.*, p. 146.

[5] *Op. cit.*, p. 12.

the excellence of many of the photographic reproductions. The photographs were made with an ordinary 5 × 7-inch bellows camera, the specimens being usually placed in direct sunlight at a low angle of incidence in order to give sharper contrast and to show better the features of relief on the impressions. The photographs showing parts of the specimens enlarged were made by supplementing the ordinary lens of the camera with an enlarging lens which fits over the front of the regular lens like a cap. To give greater contrast in these enlargements ordinary daylight was supplemented with a rather strong desk dissecting lamp fitted with "daylight" glass and by proper manipulation of this light the inequalities on the surface of the leaf impressions were shown as highlight and shadow.

In the publication just referred to Rowe gives a short list of the plants collected from beds of volcanic ash near Missoula, the list being as follows:

1. *Sequoia Langsdorfii.*
2. *Sequoia*, probably new species.
3. *Glyptostrobus europæus.*
4. *Alnus.*
5. *Carpinus*, probably new species.
6. *Cornus* or *Viburnum.*
7. *Populus balsamoides* (?)
8. Fruit near *Chinchonidium.*
9. *Taxodium occidentalis.*
10. *Taxodium.*

Accompanying Rowe's report are three plates illustrating some of the fossil plants from these beds. Plants shown on these plates are evidently the same as some of those described in the present paper, as follows: Plate VI shows at the left upper margin what is probably a piece of a leaf of *Alnus Hollandiana* Jennings, a specimen of *Populus Zaddachi* Heer being shown in the middle of the plate, while both Plates VI and VII show leaves of what I have described as a new species, *Betula multinervis.* The *Taxodium*-like sprays in Plate VIII are evidently the same as the sprays in our material which I believe to represent one of the various types of *Sequoia Haydenii* (Lesquereux) Cockerell.

The *Glyptostrobus* mentioned in Rowe's list is probably the same as the specimens in our collections which I believe belong to *Sequoia Haydenii.* The *Carpinus* is evidently the same as my *Betula multinervis*; the *Populus balsamoides* (?) I take to be *Populus Zaddachi* Heer and the *Taxodium*, like that shown in his Plate VIII, at least, is probably *Sequoia Haydenii*.

## II. Relations of the Fossil Flora from Missoula to the Nearest Eocene and Miocene Floras of the West.

The specimens collected by Mr. Douglass from near Winston appear to represent but two, or possibly three, species, as follows:

*Equisetum insculptum* Jennings
*Equisetum* sp. Vegetative buds
*Aralia longipetiolata* Jennings

These species appear not to be represented in collections described from other localities and this fact, in connection with the wide geological ranges of the genera *Equisetum* and *Aralia*, makes the collection of little value as a means of correlating this flora with other ancient floras.

The specimens from the Missoula district represent at least twenty species, ten of which I have described as new and one of which requires a new name. These twenty-one species are enumerated in the following list, the numbers in parentheses indicating from which of Douglass' localities the specimens came:

*Sequoia Haydenii* (Lesquereux) Cockerell. (165, 196)
*Sequoia oblongifolia* Jennings. (196)
*Thuyopsis gracilis* Heer. (196)
*Sabina linguæfolia* (Lesquereux) Cockerell. (196)
*Typha Lesquereuxii* Cockerell. (196)
*Cyperacites* sp. (196)
*Populus smilacifolia* Newberry. (165)
*Populus Zaddachi* Heer. (165, 196)
*Juglans pentagona* Jennings. (165)
*Betula multinervis* Jennings. (165, 196)
*Alnus microdontoides* Jennings. (165, 196)
*Alnus Hollandiana* Jennings. (196)
*Quercus approximata* Jennings. (196)
*Quercus flexuosa* Newberry. (165)
*Quercus laurisimulans* Jennings. (196)
*Ficus* (?) *prunifolia* Jennings. (196)
*Ilex furcinervis* Jennings. (196)
*Celastrus parvifolius* Jennings. (196)
*Acer oregonianum* Knowlton. (165)
*Vaccinium palæocorymbosum* Jennings. (196)

The flora represented in the Missoula collections appears closely related to that reported for the Florissant basin of Colorado.[6] Of the fifteen genera repre-

[6] Among the more important titles consulted with reference to the Florissant flora were the following:
Kirchner. Trans. St. Louis Acad. Sci., VIII, 1898, pp. 161–198, Pls. 11–15.
Cockerell. Univ. Colorado Studies, III, No. 3, 1906, 157–176. Bull. Am. Mus. Nat. Hist., XXIV, 1908, pp. 71–110, Pls. 6–10. Amer. Nat., XLIV, 1910, pp. 31–47.
Knowlton. Proc. U. S. Nat. Mus., LI, 1916, pp. 241–297, Pls. 12–27.

sented in the Missoula flora all but two are also represented in the Florissant. Three species, *Sequoia Haydenii*, *Typha Lesquereuxii*, and *Sabina linguæfolia*, apparently occur in both floras and there are other species which a further study of more complete and more abundant material might prove to be identical. Further comparisons show that to a large extent the genera having more than one species each in the two floras were largely the same. In the Missoula flora *Sequoia*, *Populus*, *Alnus*, and *Quercus* were each represented by more than one species.

One of the fossils in the Missoula collection apparently represents the species described by Knowlton from the Mascall beds of the John Day Basin, Oregon, and in a number of respects the Missoula flora seems to be rather closely allied to the Mascall flora. Eleven of the Missoula genera occur in the Mascall and, while, with the exception of the maple, perhaps none of the corresponding forms in the two floras are identical, some of them are rather closely similar. Of the genera reported as having two or more species each, the Mascall flora has *Sequoia* (with 2 or 3), *Quercus* (5 or 6), *Celastrus* (2), and *Acer* (8), as against *Sequoia* (2), *Populus* (2), *Alnus* (2), and *Quercus* (3) in the fossil flora at Missoula.

Another of the floras of the John Day Basin reported by Knowlton[7] and of interest with reference to the Missoula collections is that from what are regarded as upper Eocene[8] beds at Bridge Creek, Oregon. Comparing the Missoula flora with that of Bridge Creek it appears that seven of the fifteen genera of the former are represented also in the latter. Of the genera of the Bridge Creek flora represented by more than one species there are *Sequoia* (with 2 species), *Juglans* (3), *Betula* (4), *Alnus* (4), *Quercus* (8), *Ficus* (1), *Acer* (1). The Missoula flora has *Sequoia* (2), *Populus* (2), *Alnus* (2), and *Quercus* (3), so that, considering the relative percentage of species represented by the leading genera together with the number of genera common to the two floras, it would appear that the flora from Missoula is about as closely related to the Bridge Creek flora as to that of the Mascall beds.

Knowlton[9] has reported eighteen genera of plants among the fossils collected in the Payette formation (regarded by Knowlton as Upper Eocene)[10] from the

[7] Knowlton. Fossil Flora of the John Day Basin. U. S. Geol. Surv. Bull., CCIV, 1902, pp. 19, 89–93, 106–108, 113. *Op. cit.*, pp. 17, 89–93, 103–105, 113.

[8] Merriam, J. C. Significant Features in the History of Life on the Pacific Coast, in Nature and Science on the Pacific Coast, 1915, pp. 88–103. See also A Contribution to the Geology of the John Day Basin. Bull. Dept. Geol., Univ. Cal., II, 1901, 269–314, 285–287, 290–299; also Merriam, J. C., and Sinclair, W. J. Tertiary Faunas of the John Day Basin. Bull. Dept. Geol., Univ. Cal., V, 1907, p. 173.

[9] Knowlton. The Fossil Plants of the Payette Formation. U. S. Geol. Surv. Ann. Rpt., XVIII, Part III, 1898, pp. 721–736, Pls. 99–102.

[10] Knowlton. Succession and Range of Mesozoic and Tertiary Floras, in Willis and Salisbury, Outlines of Geologic History, Chapter X, 1910, pp. 200–211.

fossil lake beds of the Snake River in western Idaho. Eight of these genera are common to the Payette and Missoula collections. Of the Payette genera five are represented by more than one species each (*Sequoia, Myrica, Populus, Betula,* and *Quercus*) as against four such genera in the Missoula collections (*Sequoia, Populus, Alnus,* and *Quercus*). While not identical in the two floras a number of species are here also represented by similar forms.

The Lamar flora described by Knowlton[11] from the Yellowstone National Park has listed for its lower member ("Fossil forest *a*") eight of the fifteen genera which I have recognized in the Missoula collections, and there are at least five or six species closely similar in these two floras.

From what he regards as the true Green River formation "excluding Florissant and Elko Station," Cockerell[12] has compiled a list of the plant genera represented. A comparison of this list with the list of Missoula genera shows nine genera to be common to the two floras.

The following table presents in a more compact form a list of the plant genera represented in the Missoula collections together with the occurrences of the genera in the other floras discussed in the preceding pages:

Table of the Genera Represented in the Collections of Fossil Plants from the Beds of Volcanic Ash near Missoula, Montana, showing also the Occurrence of these Genera in a Number of other Fossil Floras.

| | Regarded as Upper Eocene. | | | | Middle Miocene. | |
|---|---|---|---|---|---|---|
| White River. Missoula, Mont. | Lamar. Yellowstone National Park. | Green River. Wyoming and Utah. | Payette. Snake River, West Idaho. | Bridge Creek. Oregon. | Mascall. Oregon. | Florissant. Colorado. |
| *Sequoia*...... | x | x | x | x | x | x |
| *Thuyopsis*.... | | | | | | |
| *Sabina*....... | | | | | (x) | x |
| *Typha*....... | | x | | | | x |
| *Cyperacites*... | x | x | | | x | |
| *Populus*...... | x | | x | | x | x |
| *Juglans*...... | x | x | x | x | x | x |
| *Betula*....... | | | x | x | x | x |
| *Alnus*........ | | x | | x | x | x |
| *Quercus*...... | x | x | x | x | x | x |
| *Ficus*........ | x | x | x | x | x | x |
| *Ilex*......... | | x | | | | x |
| *Celastrus*..... | x | | x | | x | x |
| *Acer*......... | x | x | x | x | x | x |
| *Vaccinium*... | | | | | | x |

[11] Knowlton. Fossil Flora of the Yellowstone National Park. U. S. Geol. Surv., Monograph XXXII, Part II, Chapter XIV, 1899, pp. 651–791.

[12] Cockerell. The Fossil Flora of Florissant, Colorado. Bull. Amer. Mus. Nat. Hist., XXIV, 1908, p. 44.

It is obviously unsafe in questions of comparison or correlation between rather closely related floras to place much reliance on such evidence as may be furnished by a small collection of fossil plants consisting mainly of leaf-impressions. Conditions of deposition and fossilization are probably very rarely effective in preserving a representative sample of a flora, unless the fossils collected are in large numbers. As far as the indications go, it appears that the Missoula specimens represent much the same kind of a flora as was preserved in the Florissant beds. Yet differences between the Missoula flora and the Green River flora, as referred to above, and generally regarded as Upper Eocene[13] in age, is by no means great. The Florissant beds are now regarded as Miocene[14], Cockerell even advancing both the Mascall and Florissant floras to middle Miocene.[15]

As far as the genera are concerned collectively there has been comparatively little change in the flora of the temperate regions of the United States since Florissant times, and, allowing for a probably gradual cooling and a decrease in moisture during the period between the Green River (Eocene) and the Florissant (Middle Miocene), it appears that the changes in genera in this latter period were likewise not great. Cockerell, comparing the Intermediate and Lamar floras on the one hand and the plants "said to occur elsewhere or in the Eocene" on the other, shows that these Yellowstone floras have "twenty-six plants specifically identical with those of the basal Eocene" and, further, "The conclusion seems to be legitimate that the Yellowstone Intermediate and Lamar floræ are Upper Eocene, or at least older than Miocene." In his discussion of the records furnished by fossils as to the distribution of the various floras through the different periods of time, Clements says[16] that "the flora of the Oligocene was essentially that of the Eocene somewhat reduced by deformation, and the plants of the Pliocene are practically those of the Miocene, but with a striking reduction," the reduction mentioned being due in part to the reduction in the area in which sedimentation and fossilization were taking place.

Of the floras referred to in the above discussion and in the table, the Bridge Creek, Lamar, Payette, and Green River are now probably best regarded as late

[13] Willis. Index to the Stratigraphy of North America. U. S. Geol. Surv., Prof. Paper LXXI, 1912, pp. 676, 758–760, 765.

[14] Knowlton. A Review of the Fossil Plants in the United States National Museum from the Florissant Lake Beds of Florissant, Colorado, With Descriptions of New Species and Lists of Type Specimens. Proc. U. S. Nat. Mus., LI, 1916, pp. 241–297, Pls. 12–27.

[15] Cockerell. The Miocene Trees of the Rocky Mountains. Am. Nat., XLIV, 1910, pp. 31–47; Some American Fossil Insects. Proc. U. S. Nat. Mus., LI, 1916, pp. 81–106.

[16] Clements, F. E. Plant Succession. Carnegie Inst. Wash., Publ. CCXLII, 1916, p. 352.

Eocene, the Mascall and Florissant as middle Miocene. Assuming this to be the case it is interesting to group together the four upper Eocene floras for purposes of comparison with the two Miocene floras. Upon doing this it appears that of the fifteen genera in our Missoula flora twelve occur also in the combined upper Eocene floras and fourteen in the combined middle Miocene floras. This comparison does not show any great preponderance in favor of the Miocene, and it is quite possible that climatic and other ecological conditions may have brought about similar groupings in the Missoula and Florissant floras somewhat out of proportion to the actual systematic relationships of the floras existing at the time these fossils were formed.

The Missoula flora probably occupied the shores and surrounding slopes of a high mountain lake. Douglass says, however: "There is doubt that the mountains were as high during the White River epoch as at the present time."[17] Cockerell and other writers have referred to Lake Florissant as a mountain lake and some of the differences between the Mascall and Florissant floras are thought by Cockerell to be possibly due to the differences between a lowland flora, like that of the Mascall, and one around a mountain lake, such as that of the Florissant.[18] I am inclined to believe that the similarity of habitat has brought about a similarity in the fossil floras from Missoula and Florissant that may have obscured to a considerable degree the actual difference of the two floras in point of time.

Two of the plants represented in the Missoula collections (*Thuyopsis gracilis* Heer, and *Populus Zaddachi* Heer) appear to be the species described and reported by Heer from the Atane beds of Greenland. These beds were regarded by Heer[19] and some other authors[20] as Miocene, but they are more likely Cretaceous or early Eocene.[21–22] A considerable number of plants described from the arctic regions by Heer and others from beds thought at that time to be Miocene appear farther south during early and middle Tertiary times. This southward shifting of floral zones is to be ascribed to corresponding climatic changes. Clements notes[23] that 'A distinct cooling is indicated by the flora of the early Eocene, and the usual accom-

[17] Douglass. New Vertebrates from the Montana Territory. Annals Carnegie Museum, II, 1903, p. 149.

[18] Cockerell. The Miocene Trees of the Rocky Mountains. Am. Nat., XLIV, 1910, p. 37.

[19] Heer, O. Flora Fossilis Arctica I, 1868, pp. 98–99, and various other pages in this and other volumes of the series.

[20] Schuchert, C. Climates of Geologic Time. In Huntington's The Climatic Factor. Carnegie Inst. Wash., Publ. CXCII, 265. 1914.

[21] Willis, Bailey. Index to the Stratigraphy of North America. U. S. Geol. Surv., Prof. Paper LXXI, 1912, pp. 705 and 838.

[22] Clements, F. E. Plant Succession. Carnegie Inst. Wash., Publ. CCXLII, 1916, p. 242.

paniment of aridity is shown by the salt and gypsum beds of the Texas formations of the period. The earliest Eocene flora, that described by Heer from Belgium, indicates a temperate climate, characterized by *Quercus, Castanea, Salix, Laurus, Hedera,* etc. Similar horizons are found in the lower Eocene of France and England. At a later stage, palms, bananas, figs, cinnamons, etc., became dominant, indicating a return to tropical conditions.' With the period of "mountain making and vulcanism" in the Oligocene there came another change to a cooler and drier climate.[23] Clements further notes[24] that the evidence indicates "that the Oligo-Miocene cycle was marked by a general climate cooler and drier than that of the Eocene, and hence by a differentiation of climates approaching that of today." And, further, "So far as dominants are concerned there appears to be little difference between the floras of the Eocene and Miocene. The dominant tree genera appear to have been about equally represented in both, and this is largely true of shrubs. . . . Thus, while the flora remained largely the same, it must have undergone marked differentiation and shifting as a result of the deformation and cooling which initiated the cycle. The northerly climax zones must have been broadened as well as pushed to the south. . . . Before the climatic effect of Oligocene deformation had disappeared the deformation cycle of late Miocene and Pliocene had begun to culminate in the Ice Age. Thus the shifting of the climatic zones took place only to the southward, as well as downwards on the mountains." The cooling during the Oligo-Miocene cycle "from a tropical or subtropical climate to a warm temperate one over much of the continent was permanent."

Assuming, then, that during the period from the late Eocene up into the Miocene there was, in general, a cooling and drying of the climate and a differentiation of climatic regions and zones and, further, that during this time there was a migration of northern plants southwards as well as down from the higher and cooler habitats to the lowlands, it seems to me not unreasonable to believe that the mountains of western Montana during the Oligocene would have been populated by the northern flora long before a similar region in central Colorado at a latitude of about six hundred miles farther south. The Missoula region would likely have been invaded by this northern flora long before the Mascall region lying to the southwest in Oregon and probably on lowlands separated but little from the western ocean either by distance or elevation. Unless exception might be made in the case of the Payette flora, I feel fairly certain that the Florissant was the only one of the fossil floras discussed which approximated very closely the Missoula flora as to the

[23] Schuchert. *Op. cit.*

[24] Clements. *Op. cit.,* pp. 364–366.

ecological conditions involved. I think that the similarity of the Missoula and Florissant floras may actually be regarded as indicating a considerable time interval during which similar stages in a southward migration of northern plants were reached in the two floras. During the corresponding disappearance of the southern plants the Missoula region would, of course, lose them before they would disappear from the Florissant and, in this connection it is interesting to note that of the southern element Florissant had *Sapindus, Diospyros, Persea, Leucœna, Annona, Ficus,* and others, while only one such species, which I doubtfully determined as *Ficus*, appears in the Missoula collection. All this leads me to believe that the collections from Missoula represent an earlier period than do the Florissant collections, a period somewhere between the late Eocene and middle Miocene, and I see no reasons for not accepting Douglass' claim that the beds belong to the White River formation and are of Oligocene age.

If we may accept the claim that there had come about a differentiation of climates it would not be unreasonable to expect a considerable difference between the flora of the Missoula White River and the Oligocene flora of the lower southeastern part of the United States, much as is the case today with the modern floras. Berry has this to say with reference to the tropical character of the Oligocene flora of the Catahoula sandstone of the Gulf Coastal Plain[25]: "Finally, the facies of the flora as a whole is that of the abundant floras found in the early Oligocene of southern Europe, notably in Provence, France, in Tryol, and in Dalmatia and Styria. Not only does it exhibit this parallelism with these European early Oligocene floras, but when the genera are considered separately it appears that almost without exception they have not been found in what are now temperate latitudes in any beds younger than Oligocene." In general this was a tropical flora and the climate along the Gulf Coast at that time was evidently much more tropical than now.[26–27] There was later a general cooling, possibly also a shifting of ocean currents bringing about a change from subtropical to cold-water conditions, with evidently somewhat corresponding changes in the flora of the adjacent coasts. Berry has shown by a study of the flora of the Calvert formation from Virginia and the District of Columbia that by the time of the middle Miocene the climate in this region

[25] Berry, E. W. The Flora of the Catahoula Sandstone. U. S. Geol. Surv., Prof. Paper XCVIII–M, 1916, pp. 227–243, Pls. 55–60.

[26] Berry, E. W. A Study of the Tertiary Floras of the Atlantic and Gulf Coastal Plain. Proc. Amer. Phil. Soc., L, 1911, 311–315.

[27] Dall, W. H. Contributions to the Tertiary Fauna of Florida, Part VI. Trans. Wagner Free Inst., III, 1903, p. 1594.

was cooler, probably only warm-temperate.[28] "The Calvert flora was a coastal flora of strikingly warm-temperate affinities, comparable with the existing coastal floras of South Carolina and Georgia along the south Atlantic coast or with those along the coast of the Gulf of Mexico from western Florida to eastern Texas. The climate of the Chesapeake Miocene epoch, cooler undoubtedly than that of the Apalachicola or preceding epochs, was neither cold nor cool temperate."

It is evident that the Oligocene and middle Miocene floras of the middle and southeastern Atlantic Coastal Plains were related ecologically, and, especially as to the climatic aspect, were related to the Oligocene and middle Miocene floras of the West in very much the same manner as are the modern floras of those regions. I can see nothing in either the character or ecological relationships of the old southeastern floras that might serve as an argument against our belief in the Oligocene age of the Missoula flora.

## III. Ecological Conditions Indicated by the Fossil Flora from Missoula.

As to the ecological relationships of the flora around the old Missoula basin, it is interesting to compare the fossil flora with that, which in the case of a shower of volcanic ash we might suppose would be represented by plant materials imbedded under conditions likely to lead to fossilization in the basins of some of the lakes now to be found in western Montana and Idaho. The plants preserved in the Missoula fossil collections were practically all woody plants, evidently mostly trees, and I have found particularly useful for the purposes of this comparison the biological reconnoissances of Flathead Lake and several other smaller lakes in western Montana by Elrod,[29] and the more detailed studies of the forests of the Flathead Valley by Whitford.[30] To a considerable extent, also, I have relied upon first-hand information gained during two weeks in the summer of 1915 which my wife and I spent in botanizing around Lake Newman, along the Washington-Idaho state boundary line about one hundred and sixty miles west of Missoula.

Whitford's classification of the vegetation in the Flathead Valley, western Montana, in the midst of rugged mountains, shows it to consist of five main divisions, as follows: I. Meadow (hydrophytic); II. Englemann Spruce Forest (meso-

[28] Berry, E. W., Physical Conditions indicated by the Flora of the the Calvert Formation. U. S. Geol. Surv., Prof. Paper XCVIII–F, 1916, p. 66.

[29] Elrod, M. J. A Biological Reconnoissance in the Vicinity of Flathead Lake. Univ. Mont. Bull., X, 1902, pp. 91–182, Pls. 18–46. (Biological Series III.)

[30] Whitford, H. N. The Forests of the Flathead Valley, Montana. Bot. Gaz., XXXIX, 1905, pp. 99–122, 194–218, 276–296.

hydrophytic); III. Western Larch—Douglas Spruce Forest (mesophytic); IV. Douglas Spruce—Bull Pine Forest (meso-xerophytic); and V. Prairie (xerophytic).

Numbers I, II, III, and V of Whitford's divisions contain more or less abundantly species corresponding to those represented in the Oligocene flora of Missoula. The Meadow (I) is usually along the end or border of a lake or else in a wet swampy depression, and such a meadow with subsequent filling or draining will tend to be invaded and eventually succeeded by Spruce Forest (II).

From the articles cited I gain that most of the meadows have, on the hummocks or as a bordering thicket, the advance guard of the spruce forest in the form of willows (*Salix*) and alders (*Alnus*). The thickets formed by these plants are eventually entered by spruce (*Picea Engelmanni*) accompanied by poplars (*Populus angustifolia* and *P. tremuloides*), birches (*Betula papyrifera*), and sometimes *Echinopanax horridum*, *Rhamnus alnifolia*, and *Cornus stolonifera*. For the purposes of the present discussion, the wet meadow and spruce forest will be treated as one unit. They are both situated close to the water or are in the central part of a wet depression and, often the shore of the lake may be so dry that there is no meadow, the spruce forest bordering the shore directly, with perhaps but a narrow fringe of alders, willows, and a few other plants.

Three of the genera mentioned in the above paragraph were present also in the Oligocene flora of Missoula, these three genera including five of the fossil species. Added to these five, should be the fossil species of *Typha*, *Cyperacites*, *Vaccinium*, and *Ficus*, which must have occupied either the wet meadow, its invading and surrounding thickets, or the adjacent wet woods. Thus considered, the meadow or its immediate borders or adjacent wet woods in the Flathead Valley would be quite likely to contribute to the waters of the nearby lake leaves of representatives of at least five of the genera found in the Oligocene fossil flora from Missoula, while, considered from the standpoint of systematic and ecological equivalents, similar habitats around a lake in the Missoula district in Oligocene times might easily have contributed at least nine of the twenty-one species found among the Missoula fossils.

Whitford's third class, the one having the habitat next drier than the spruce forest and thus usually the one next higher on the slope from the lake basin, is the Western Larch-Douglas Spruce forest. Characterizing this forest are the larch (*Larix occidentalis*), Douglas Spruce (*Pseudotsuga mucronata*), and accompanying them are the Lodge-pole Pine (*Pinus Murrayana*), Lowland Fir (*Abies grandis*), White Pine (*Pinus monticola*), Engelmann Spruce (*Picea Engelmanni*), White Cedar (*Thuya plicata*), and occasionally *Abies lasiocarpa*, *Pinus ponderosa*, *Tsuga heterophylla*, and some other chiefly deciduous trees and shrubs.

With gentle slopes rising from the lake basins this forest will usually be found at some little distance from the open water, but on higher, drier, well-drained soil on steeper slopes or benches along the lake shore, such forests occur close to the open water. At Newman Lake near the Idaho-Washington boundary line patches of this association occupy soil not over fifteen feet from open water and extending down upon levels not over three feet above lake-level. Such a forest might easily become a strong competitor with the meadow-spruce forest in contributing leaves and other materials to a bed of volcanic dust accumulating in the lake close by. The old ecological equivalent of this habitat probably furnished for fossilization in the Oligocene lake-bed at Missoula the two species of *Sequoia*, the *Thuyopsis* (represented in our Northwest now by *Thuya*), the maple (*Acer*), the walnut (*Juglans*), and perhaps some of the oaks (*Quercus*).

On sandy or rocky habitats or on dry uplands and slopes, where not too cold, the next drier habitat to that occupied by the Larch-Douglas Spruce forest is that of the Douglas Spruce-Bull Pine forest. On rocky or dry sandy soils around Newman Lake this forest comes down practically to the water's edge. Whitford[30a] notes that: "If the outcrop is near a large body of water like Flathead Lake, *Juniperus scopulorum* is one of the first trees." The forest is mainly composed of the Yellow Pine or Bull Pine (*Pinus ponderosa*) and Douglas Spruce. Such a forest around an Oligocene lake-basin at Missoula could thus have contributed readily from a rocky cliff or promontory twigs of the Juniper (*Sabina*) or with the somewhat warmer conditions indicated by the presence of the oaks and possibly a fig, the Juniper might have come from a sandy shore or from sand dunes such as are now so characteristically covered with the Red Cedar (*Juniperus virginiana*) along the shores of Lake Erie and the lower end of Lake Michigan.

Assuming that the climate in the Oligocene lake basin at Missoula was warmer and probably drier (*see* p. 394) than that now prevailing in the Flathead Valley, it appears probable that the habitat occupied by the Oligocene equivalent of the Douglas Spruce-Bull Pine forest occupied a larger area, or at least crowded more closely the more moist areas around the basin. I believe that this habitat is the one which probably furnished the oaks, or at least most of them, and possibly also the Holly (*Ilex*) and *Celastrus*, although modern species of both of these genera also occur in more moist habitats. The Oligocene oaks were apparently xerophytic, as indicated by the nature of the leaf impressions, and I take them to have been comparable to the modern live-oaks, chestnut-oaks, and shingle-oaks so characteristic of moderately xerophytic habitats in the eastern, southeastern, and southwestern parts of the United States.

[30a] *Op. cit.*, p. 216.

As indicated in the preceding discussion, the fossils in the volcanic beds at Missoula might readily have been contributed to the waters of an Oligocene lake, in a climate somewhat warmer than now prevails in that region, by a series of vegetational associations ranging from wet meadow to moderately xerophytic oak-forests on rocky or sandy shores, all of these vegetational associations in close proximity, at least here and there, to the waters of the lake.

## IV. Remarks on the Fossil Flora from Winston, Montana

The collections from the consolidated mud from Winston apparently belong to the same general age as the Missoula collections. As noted earlier in this paper there are but two species represented, a small *Equisetum* and a plant which I have referred to *Aralia*. Neither of these plants offer much basis for correlation with other fossil floras. *Equisetum* occurs in all of the late Eocene and middle Miocene floras listed in the preceding table, excepting only Bridge Creek, and it, or the forms referred to *Equisetites*, range from the Paleozoic up to modern times, so that its presence means little as to the time relations of the beds in which it occurs. *Aralia* occurs in the Lamar and Green River floras (late Eocene) and in the Florissant (middle Miocene). Its range from the upper part of the lower Cretaceous up to modern times makes it, too, of little use for purposes of correlation. If there is other evidence, as for instance, from animal fossils, for believing that these plants were of Oligocene age I can see no objection to such a view from any evidence to be furnished by the plant fossils. Ecologically the *Equisetum* and *Aralia* might readily have been a part of the vegetation believed to have grown around the Oligocene lake at Missoula; the *Equisetum* in shallow water with sandy bottom, the *Aralia* in the thickets invading the wet meadow or in the moist woods.

## V. Descriptions of the Species in the Oligocene Flora of Missoula, Montana, and of a few Species from Winston, Montana.

### 1. **Equisetum insculptum** Jennings, sp. nov. (Plate XXII, Fig. 2.)

The specimen consists of a mould of a piece of stem about 3 cm. long, this mould being mainly filled with the corresponding cast. The mould and cast reproduce in great detail the minute features of the outside of the stem. The stem was about 3 mm. in diameter but was compressed in fossilization to about 4 mm. and it had eighteen ridges about 0.5 mm. apart, these being quite prominent and each having two distinct rows of papilla-like tubercles. In the rather deep and rounded furrows there are fine but distinct and closely set silex ridges running crosswise and

there are longitudinal lines indicating the position of two rows of stomata. The character of the impression suggests a species with a rather firm and strong stem-wall, such as is the case in the living *Equisetum hyemale* Linnæus.

The one specimen upon which this record is based comes from "Locality 139," near Winston. So far as I have been able to discover among the various publications relating to fossil *Equisetaceæ*, there have been no fossil species described in which the markings have been so beautifully preserved as in this specimen. The most nearly related species are, perhaps, *Equisetum wyomingense*, described by Lesquereux from the Green River group of Wyoming, and the *Equisetum* studied by Knowlton from the Payette of Idaho, both probably Eocene in age. Among living species, *Equisetum variegatum* var. *Jesupi* A. A. Eaton, which is probably a hybrid between *E. variegatum* and *E. hyemale*[31] is very closely similar, having the double row of carinal tubercles, small stem, and cross-bands of silex in the furrows.

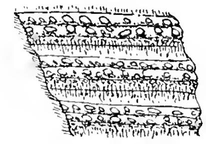


FIG. 1. *Equisetum insculptum* Jennings. Sketch to show details of markings on the stem shown in Plate XXII, fig. 2. Enlarged about fifteen diameters.

The genus *Equisetum*, or *Equisetites*, as most of its older representatives have been called, is recorded from at least as far back as the Paleozoic. Excepting possibly for a considerable diminution in size, these plants have changed but little up to the present time and the various species are of relatively little stratigraphic value.

As the Winston species seems not to be the same as any of the species before described, I am designating it as new, the specific name *insculptum* being used for it on account of the unusually distinct and bold markings on the outer surface of the stem.

2. **Equisetum** sp. (PLATE XXII, FIG. 1.)

This is a poorly preserved specimen from the Winston locality representing a piece of a stem, about 17 mm. long and 3 mm. wide, at the apex of which is indicated a cluster of three branches, only two of which are preserved with any degree of distinctness. The most perfect of the branches consists of a short stem about 1 mm. in diameter and 11 mm. long. This probably is a bud from the basal part of a plant, just as may be found on some of the Equisetums of today, and such as have been described several times in paleobotanical literature.

The specimen may represent a plant of the species to which I have given the name *Equisetum insculptum*, found at the same place, but aside from a probable similarity in size and the mere fact that they were taken from the same locality there is no basis for such an assumption.

[31] Holden, Ruth. The Anatomy of a Hybrid *Equisetum*. Am. Journ. Bot., II, 1915, pp. 225–237.

3. **Sequoia oblongifolia** Jennings, sp. nov. (Plate XXIII, Figs. 1 and 1*a*.)

Among the various fossils representing *Sequoia* in the White River material from Douglass' "Locality 196", near Missoula, Montana, there are three specimens showing fragments of leafy twigs, which can not be satisfactorily referred to any of the various kinds of leafy twigs of *Sequoia Haydenii*, but apparently resemble rather closely the specimens from Greenland described and figured by Heer as *Sequoia brevifolia*, as follows:[32] " S. foliis oblongis, basi angustatis, adnato decurrentibus, confertis, patentibus, planis, distichis, apice obtusis, infimis squamæformibus, adpressis."

As shown by Heer's figures and later by Lesquereux[33] and by Knowlton,[34] the leaves of the White River plant were more strictly oblong, with straight sides, and the base more abruptly rounded, while the leaf-blades were about one-half longer and wider. The White River specimens show the leaves about 7–10 mm. long by 2–2.8 mm. wide, oblong, the apex rounded and apiculate. The midrib is fairly strong, there being also faint furrows on each side of it and there are also faint indications of numerous fine longitudinal striæ. The leaves were evidently quite thick and stiff and the impressions show irregular cross-furrows and ridges, such as are evident in dried specimens of many living species of *Sequoia*, *Taxus*, *Podocarpus*, etc., having thick leaves. The base of the leaf is strongly decurrent, while the leaves apparently spread distichously and at a wide angle, the blade often curving enough to place the apex of the leaf at almost a right angle with the branch.

In general outline the leaves resemble some of the fossils described as *Taxites* and *Taxodium*, but the quite strongly decurrent leaf base would appear to relate it to *Sequoia*. It is also similar, possibly very close to some of the specimens referred by some authors to *Sequoia Langsdorfii*, but I have preferred to refer the Missoula specimens to a distinct species on account of the more decidedly oblong leaves with the apex blunter than seems to be the case in *S. Langsdorfii*.

4. **Sequoia Haydenii** (Lesquereux) Cockerell. (Plate XXIII, Figs. 3, 4, 6; Plate XXIV, Figs. 1, 2, 3; and Plate XXII, Figs. 3, 3a, 4, and 5.)

*Hypnum Haydenii* Lesquereux, Bull. U. S. Geol. and Geogr. Surv. Terr., I, 1875, p. 383; Rept. U. S. Geol. Surv. Terr., VII, 1878, p. 44, Pl. 5, figs. 14, 14*b*.

[32] Heer. Flora Fossilis Arctica, I, 1868, pp. 92 and 93, Pl. 2, figs. 23 and 23*b*.

[33] Lesquereux, Tertiary Flora, U. S. Geol. Surv. Terr., VII, 1878, p. 78, Pl. 61, figs. 25–27.

[34] Knowlton. Flora of the Montana Formation. U. S. Geol. Surv., Bull. CLXIII, 1900, p. 27, Pl. 4, figs. 1–4.

*Sequoia affinis* Lesquereux, U. S. Geol. and Geogr. Surv. Terr., Bull. I, 1875, p. 384 (1876); Tertiary Flora, Rept. U. S. Geol. Surv. Terr., VII, 1878, p. 75, Pl. 7; figs. 3–5 and Pl. 65, figs. 1–4.

*Glyptostrobus Ungeri?* Heer. Lesquereux, Cretaceous and Tertiary Floras, Rept. U. S. Geol. Surv. Terr., VIII, 1883, p. 139, Pl. XXII, figs. 1–6a.

*Sequoia Haydenii* (Lesquereux) Cockerell, Science, XXVI, 1907, p. 447; Pop. Sci. Monthly, LXXIII, 1908, p. 122, text-fig.; Bull. Amer. Mus. Nat. Hist., XXIV, 1908, p. 78; Amer. Nat. XLIV, 1910, p. 32, fig. 3, p. 36.

The most abundant conifer in the material studied is a *Sequoia* which seems to present a remarkable amount of variation in both size and form of leaf. After much study I have decided to pursue the course adopted by Cockerell and Knowlton with respect to the similar series of Sequoias found in the Florissant beds and to regard these all as belonging to the plant described by Lesquereux as *Sequoia affinis* and *Hypnum Haydenii*.

One common type of twig among these specimens is small and densely leafy, the largest of this type (Plate XXII, figs. 3 and 3*a*) being about 7 cm. long, irregularly pinnately branched, the leaves being mainly lanceolate or elliptic-oval, ranging up to a size of about 3 to 4 mm. long by 1 mm. wide, tapering into a decurrent base about half as wide, and tapering above into an acute or somewhat obtuse apex. The midrib is not prominent, often not showing at all. The leaves spread at an angle of about 45°, being mostly somewhat recurved and being quite uniform in size throughout the length of the twigs. These specimens match quite closely the descriptions and figures of *Sequoia Couttsiæ* Heer,[35] but the leaves from the Montana collections are scarcely or not at all falcate and they are more spreading than the Bovey Tracy specimens, as shown by Heer's plates. Twigs of this type are represented in material from Douglass' "Locality 196" at Missoula, but not from Winston. This is evidently also the same plant as that occurring in some of the Tertiary rocks of the Western United States and referred in the past to *Glyptostrobus europæus*.

In association with the leafy twigs, but not attached to them, is a short twig (Plate XXIII, fig. 4) at the apex of which are three cones, at least one of which, and probably all three, belong to the twig. The cones are oblong, about 6 mm. thick by 8 mm. long, rounded at the ends, the scales being 3–4 mm. long, with their shank 4-angled, or perhaps some of them 3-angled, widening to about one and one-half mm. at the apex, where they are capped by a thin flattened shield about

[35] Heer. Fossil Flora of Bovey Tracy, Trans. Royal Soc. London, CLII, 1862, pp. 1051–1055, Pl. 59, figs. 1–19, Pl. 60, figs. 1–45, and Pl. 61.

2–2.5 mm. wide. The scales are loosely placed on the axis of the cone, the peltate tops being only rarely in contact with each other and they are little or not at all mucronate. These cones agree fairly well with the figures given by Saporta[36] for *Sequoia Couttsiæ*, but, as was also the case in the comparison of them with the figures of the Bovey Tracy specimens, the Missoula cones are somewhat smaller and are distinctly oblong.

In the Missoula material there is a small leafy shoot (Plate XXII. fig. 5) about 12 mm. long, but with a rather thick central axis and clothed with leaves, which range from scale-like organs less than 2 mm. long at the base to ascending lanceolate bracts at the apex about 4–5 mm. long. The upper bracts apparently form a cup or campanulate structure resembling the arrangement of the perigonial bracts at the apex of a vigorous *Polytrichum* shoot. Indeed, the fossil suggests at once a vigorous moss shoot. It appears, however, to be of the same nature as the fossil described rather doubtfully by Lesquereux (*l.c.*) under the name of *Hypnum Haydenii*. Lesquereux's specimen has occasioned considerable discussion, Mrs. E. G. Britton and Dr. Arthur Hollick having referred it[37] to some conifer resembling *Juniperus communis* L., to young growing branchlets of which the fossil shows considerable resemblance; while Cockerell (*ll.cc.*, above) refers the specimen to *Sequoia affinis* Lesquereux; and Knowlton, still later,[38] publishes it as *Juniperus? Haydenii* (Lesquereux) Knowlton.

The Missoula specimen is found to resemble very closely the short branchlets which constitute the pedicels of the cones of *Sequoia sempervirens* Endlicher. As compared with such branchlets on specimens of the Redwood in the Carnegie Museum (*Jennings*, Mill Creek Valley above Muir's Woods, Cal., 1915) the fossil is found to have about the same size, the bases are similarly blunt and clothed with short, thick, scale-like leaves, the apex having longer, more slenderly tipped bracts arranged in campanulate fashion. In view of these similarities I am following Cockerell in referring the moss-like twig to Lesquereux's *Sequoia affinis*, which, however, is required to be known as *Sequoia Haydenii* on account, unfortunately, of the prior publication of the supposed moss.

The third type of specimen, which I am including under the name *Sequoia Haydenii*, consists of rather densely complanately leaved twigs up to 12 cm. long (Plate XXIII, fig. 6) and with leaves spreading collectively to a width of 7–30 mm. The leaves become abruptly much shorter for a distance of 5 cm. or more at the base

[36] Saporta. Annales des Sciences Naturelles, 5 Series, IV, 1865, Pl. 2, figs. 2*a* and 2*d*.

[37] Britton, E. G. & Hollick, A. Bull. Torrey Botanical Club, XXXIV, 1907, pp. 139–140.

[38] Knowlton, F. Proc. U. S. National Museum, LI, 1916, pp. 249–250.

of the twigs. The median leaves are linear-lanceolate to narrowly linear-oblong; varying on different twigs from 5–17 mm. in length and from 1–2 mm. in width; somewhat falcate, spreading at an angle of 50–70°. The apex of the leaf is usually rather acute, sometimes more acuminate, while the base tapers to an oblique, somewhat thickened, and rather widely decurrent insertion. This latter character forms perhaps the most easily observable distinction between this and the somewhat smaller-leaved *Taxodium dubium* (Sternberg) Heer, to which there is a fairly close resemblance in general aspect. Heer[39] figures another character which apparently distinguished *Sequoia* from *Taxodium*. In *Sequoia* there are strong cell-walls running from the midvein to the margin of the leaf and their course is often marked by faint cross-lines on the outer surface of the leaf. In some of the Missoula fossils these markings show quite distinctly. There is also a close resemblance to plates and descriptions of *Sequoia Langsdorfii* (Brongniart) Heer which is a rather characteristic Miocene species of Europe and has been reported from a number of localities in the western part of the United States. It would seem not at all improbable that some of the Western specimens reported as *Sequoia Langsdorfii* may belong to the same species as do ours from Missoula.

Specimens of the complanately leaved type occur in the material from both of Douglass' localities 196 and 165.

### 5. **Thuyopsis gracilis** Heer. (Plate XXIII, Fig. 5.)

*Thuyopsis gracilis* Heer, Flora Fossilis Arctica, VII, p. 59, Pl. XX, fig. 16; Schenck, Palæophytologie, Zittel's Handbuch der Palæontologie, II, 1890, pp. 322–323, fig. 223.

The specimens which I have referred to this species consist of three small leafy twigs, the longest of which is less than a centimeter in length. This longest twig, shown in figure 5, matches so closely the figure of Heer's species as to leave little doubt as to the identity of the two plants. In our plants the leaves are appressed, thick, smooth, evidently shining, those on the upper face of the twig being 3–4 mm. long, 2–2.5 mm. wide, the lower two-thirds of only the margins being covered by the overlapping edges of the adjacent pair of lateral leaves, the back of the leaf having a median ridge about one millimeter wide and bordered on each side by a slight furrow, which extends uniformly the whole visible length of the leaf. The apex of the leaf is rather blunt, thick, and incurved. The lateral leaves are apparently inserted a little lower on the twig, being about the same length as the others, but somewhat narrower, the apex thickened and incurved. This approxi-

[39] Flora Fossilis Arctica, I, 1868, Pl. 2.

mation of the leaves into groups, almost whorls, gives the twig a peculiar jointed appearance.

Cockerell has identified a fossil from the Florissant[40] as *Heyderia coloradensis* Cockerell, comparing it to the modern *Libocedrus decurrens* Torrey (*Heyderia decurrens* Koch). This plant is evidently very similar to the plant from Missoula, which I have called *Thuyopsis gracilis* Heer, but the specimens from Missoula show strongly flattened shoots with short and wide leaves, the lateral leaves spreading rather widely, and, so far as leafy twigs of such conifers can be taken to indicate relationships, I think the evidence shows that they are *Thuyopsis* rather than *Libocedrus*.

*Thuyopsis gracilis* was described by Heer from Greenland, from beds which he regarded as Miocene, but which are now regarded as being older, perhaps Eocene or even Cretaceous. The modern representatives of the genus consist of one species native to Japan (*Thuyopsis dolobrata* Siebold & Zuccarini) and the variety *nana* Siebold & Zuccarini (*T. lœtevirens* Lindley) native to China. So far as I know, *Thuyopsis gracilis* has not before been reported on the North American continent. The Montana specimens came from only one locality, Douglass' "Locality 196" at Missoula.

6. **Sabina linguæfolia** (Lesquereux) Cockerell. (Plate XXIII, Fig. 2.)

*Glyptostrobus europæus* Heer. Lesquereux, Tertiary Flora. Rept. U. S. Geol. Surv. Terr., VII, 1878, p. 74, Pl. 7, figs. 1 and 2.

*Widdringtonia linguæfolia* Lesquereux, Cretaceous and Tertiary Floras, Rept. U. S. Geol. Surv. Terr., VIII, 1883, p. 139, Pl. 21, figs. 14 and 14*a*.

*Sabina linguæfolia* (Lesquereux) Cockerell, Univ. Col. Studies, III, 1906, p. 175; Knowlton, Proc. U. S. Nat. Mus., LI, 1916, p. 249, Pl. 14.

These specimens consist of several fragments of leafy twigs, mostly less than a centimeter long, some of them irregularly and closely pinnately branched. The leaves are 4-ranked, thick, with a rather prominent dorsal ridge, which is especially sharp at the apex. The branches are evidently complanately flattened, but the smaller twigs appear almost as thick as wide. The facial leaves on the larger twigs are about 1–1.5 mm. long, the lower half overlapped on the margins by the lateral leaves, the exposed portion of the leaf rhomboid, almost as wide as long, the apex acute and closely appressed, thick, with a sharp dorsal ridge. On these larger twigs the lateral leaves are about the same size or perhaps a little longer, their lower margins meeting over and below the lower part of the facial leaf for a

[40] Cockerell. Bull. Amer. Mus. Nat. Hist., XXIV, 1908, p. 78.

distance often half that of the length of the exposed part of the facial leaf. These lateral leaves are thick, ovate, somewhat bluntly acute, the tips spreading at an angle of about forty-five degrees. On the larger twigs the successive pairs of lateral leaves do not reach the next higher ones, this giving the twigs a jointed appearance, but on the smallest twigs both the facial and lateral leaves are imbricate throughout. On these smaller twigs the leaves are mostly less than 1 mm. long, scale-like, thick, rather sharply dorsally carinate, there being some indication of a gland at about the middle, the apex acutish, or on the lateral leaves often rather obtuse.

The specimens only occur in material from Douglass' "Locality 196," Missoula, and they are all in mixture with detached *Sequoia* leaves and unidentifiable fragments of wood, bark, etc., a general mixture of small floating fragments, such as can often be seen stranded along more or less protected shores and banks during quiet weather, or more rarely water-logged and forming a layer on the bottom of a quiet pool.

The similarity of the foliage on these twigs to that of *Chamæcyparis Ehrenswardi* Heer is such that confusion might readily occur in attempting to state the geological range of the two genera. *Sabina linguæfolia* is now known to occur in the Florissant beds of Colorado, middle Miocene, and I would have little hesitation in referring to the same species, or at least a very closely related one, the fragment described and figured by Knowlton from Van Horn's ranch, John Day basin, Oregon, middle Miocene.[41] The fossils from the White River beds differ scarcely at all from impressions such as would be formed by the modern Rocky Mountain Juniper, *Sabina scopulorum* (Sargent) Rydberg, occurring on foothills and bluffs throughout the Rocky Mountains.

7. **Typha Lesquereuxi** Cockerell. (Plate XXIX, Fig. 4).

*Typha latissima* Lesquereux, The Cretaceous and Tertiary Floras U. S. Geol. Surv. Territories, VIII, 1883, p. 141, Pl. 23, figs. 4, 4*a*. Not *T. latissima* Al. Braun.

*Typha Lesquereuxi* Cockerell, Fossil Plants from Florissant, Colorado, Bulletin of the Torrey Botanical Club, XXXIII, 1906, p. 307; *idem*, The Fossil Flora of Florissant, Colorado, Bulletin of the American Museum of Natural History, XXIV, 1908, pp. 77–110, Pls. 6–10.

The specimen consists of an impression of a leaf fragment about 1.5 cm. long by 1.1 cm. wide, marked with fine longitudinal parallel veins about 1 mm. apart.

[41] Knowlton. Fossil Flora of the John Day Basin, Oregon. U. S. Geol. Surv., Bull. CCIV, 1902, p. 26, Pl. 1, fig. 3.

Between these fine veins are traces of much finer veinlets, while the surface is marked somewhat more strongly by fine transverse lines running from one vein to the next. The leaf appears to have been fairly thick and smooth. Impressions on the same piece of rock are probably those of stems but are indistinct and indefinite.

According to the reports *Typha* appears first in the eastern United States in the middle Cretaceous (Raritan and Magothy), next in the Eocene in Canada (Paskapoo) and in Europe, then in the Oligocene of Europe and the Miocene of Florida and Europe. The genus now contains about nine species well distributed in fresh-water swamps in temperate and tropical regions.

Our specimen appears to be the same species as that figured by Lesquereux (*l.c.*) and by Cockerell from the Florissant (*l.c.*), and, judging from the wide distribution of some of the modern species, it is not unlikely that this species had a wide distribution in the Oligocene and mid-Tertiary swamps of western temperate America.

### 8. **Cyperacites.** (Plate XXIX, Fig. 3.)

There has been referred to *Cyperacites* a piece of a leaf measuring about 4 cm. long by 4 mm. wide. The midrib is narrow and prominent, and there are indications of a less prominent vein on each side of it, as well as faint indications of other longitudinal markings. The impression is practically uniform in width throughout its length, and the indications are that the leaf was a leathery one with a glossy surface, such as might be the case with coniferous leaves, as, for example, *Podocarpus* or *Taxites Olriki*, or with some of the species of the *Cyperaceæ* of the present period, when growing in more or less xerophytic habitats. However, in the absence of stems, flowers, or fruits, the identification of such a fragmentary specimen must remain very uncertain. The specimen might with almost equal propriety be regarded as representing a species of *Podocarpus*.

The specimen is from "Locality 196," Missoula.

### 9. **Populus Zaddachi** Heer. (Plate XXV, Figs. 1, 2; Plate XXVI, Figs. 1, 1*a*, 2, 3, 5, 6, and Plate XXIV, Fig. 6.)

*Populus Zaddachi* Heer, Flora Fossilis Arctica, I, 1868, pp. 98–99, Pls. VI, figs. 1–4, and XV, fig. 1*b*; Lesquereux, The Tertiary Flora, U. S. Geological Survey of the Territories, VII, 1878, p. 176, Pl. XXII, fig. 13; *idem*, The Cretaceous and Tertiary Floras, U. S. Geological Survey of the Territories, VIII, 1883, p. 158, Pl. 31, fig. 8.

The leaves are large, the blades being 5.5–16 cm. long, by 3–12 cm. wide, ovate to broadly ovate, or the smallest ones more narrowly ovate, the base broadly

rounded to a rather narrow and shallow cordate sinus, the insertion of the petiole having two well-marked glands at each side, or even with a glandular or thickened rim on the outer side, as in some modern species of *Populus*, the upper part of the leaf being somewhat acuminate with a rather obtuse apex. The leaves are seven- to five-ribbed, the lowest pair of ribs weak and short, swinging back into the broadly rounded basal curves, these, as well as all ribs, looping in camptodrome fashion; the next upper pair in the seven-ribbed leaves leaving the insertion at about right angles and extending well out to the margin of the blade in a broad upturned curve; the pair next to the midrib are stronger, ascending at an angle of about 45–35 degrees, approaching the margin at about two-thirds the distance from base to apex of the leaf, and during the upper half or two-thirds of their course throwing off from their lower side widely diverging and rather strong branches, which, swinging around and forking, loop together in camptodrome fashion within 2–5 mm. of the leaf-margin. The veinlets from these latter loops usually also form a series of much smaller loops from which faint veinlets run out to the small crenate teeth. The uppermost pair of ribs is only about half as wide as is the midrib, having thus about the same thickness as the lateral veins from the midrib itself. The midrib is strong, about 1 mm. wide, sending out four to seven pairs of widely-spreading, upwardly curving veins, either approximately opposite or alternate, the strongest of these veins usually arising at about the middle of the leaf or slightly below. Other fainter veins are thrown off at wide angles, some of the finest of them at practically right angles, especially from the lower half of the midrib. As compared with most broad leaves, the ultimate meshwork is rather coarse. The texture of the leaves appears to have been rather thick and leathery and the surface smooth, the larger nerves being deeply impressed on the upper surface of the leaf and rounded but fairly prominent below.

In general shape the larger of these leaves resemble very closely those described by Newberry as *Catalpa crassifolia*[42] or later as *Aristolochia cordifolia*[43]. The character of the teeth and the glandular insertion of the petiole can leave little doubt, however, as to the propriety of placing these specimens in the genus *Populus*. Berry[44] in connection with the description of *Grewiopsis tennesseensis* from specimens from the Wilcox beds of Texas and Tennessee, calls attention to their resemblance to "the numerous forms from Greenland, Europe, and western North

[42] Newberry. Annual Report, New York Lyceum of Natural History, IX, 1868, p. 56.

[43] Newberry. Illustrations of Cretaceous and Tertiary Plants, U. S. Geological Survey, IX, 1878, Pl. 25, fig. 7; U. S. Geological Survey, Monograph, XXXV, 1898, p. 90, Pl. 39; Pl. 40, fig. 7; and Pl. 60, fig. 4.

[44] Berry. The Lower Eocene Floras of Southeastern North America, U. S. Geological Survey, Professional Paper XCI, 1916, p. 286.

America that are commonly referred to the genus *Populus,* as *Populus arctica* Heer, *Populus Zaddachi* Heer, *Populus cuneata* Newberry (a variable and common form of the Fort Union Eocene), *Populus genetrix* Newberry, *Populus paleomelas* Saporta, or *Populus glandulifera* Heer." He appears to doubt that these various species belong to *Populus* and notes that "it is singular that the Arctic and early American forms are palmately and not pinnately veined, like the modern species, and present in a varying degree other distinctive features." In connection with this opinion attention should be called to the distinctly palmate ribbing of our common modern *Populus deltoides,* certainly just as distinctly five-ribbed as are the five-ribbed leaves of the fossils at hand. In addition to the agreement in venation, the presence of glands on the crenulations and at the insertion of the petiole are further arguments for referring at least the Missoula fossils to *Populus.* Sinnott and Bailey[45] conclude among other things that "The primitive angiosperm leaf was palmate in type, probably lobed, and was provided with three main bundles which arose separately at the node;" and "This conclusion is based on evidence from paleobotany, that the palmate leaf was more frequent in the Cretaceous and Tertiary than at present."

The petiole, when preserved, is slender, but apparently rather stiff and woody, and distinctly enlarged at its base. The length of the petiole was 5.7 cm. in a leaf with a blade about 12 cm. long. Another specimen, in which the blade of the leaf was about 13 cm. long, had a petiole 6.2 cm. long.

The genus *Populus* is comparatively a very old one, its oldest known species probably being *Populus primæva* Heer, from the Kome beds of western Greenland, which are presumably of Potomac age[46] (upper part of the Lower Cretaceous). From this time on the number of species reported increases up towards the Eocene, from which period there are perhaps forty species already reported from the United States alone, many of these species resembling very closely some of the living species. The range of *Populus,* beginning in the far north in the Cretaceous, extended during the latter part of the Cretaceous and in the Tertiary quite generally over the temperate regions of the northern hemisphere. In western North America there have been described from the Fort Union beds alone about as many species (25) as there are now of living species of poplars in the whole world.

The range of *Populus Zaddachi* Heer is wide, the species having been reported

[45] Sinnott and Bailey. Investigations on the Phylogeny of the Angiosperms, 5, American Journal of Botany, II, 1915, pp. 1–23.

[46] White and Schuchert. Cretaceous Series of the West Coast of Greenland, Bulletin of the Geological Society of America, IX, 1898, pp. 365–367.

from eastern Germany and western Greenland[47] and, in North America proper, from Alaska, California, Colorado, Wyoming, Montana, and Dakota, from beds variously ranging from the lowest part of the Eocene up to the Miocene.

The smallest of the leaves among the specimens are very likely those at the apex of rapidly growing shoots, and they are much more narrowly ovate to even lance-ovate than are the larger leaves, exactly as may be observed in *Populus balsamifera* and other living species. Among the Missoula specimens is an impression of a leaf-blade about 4 cm. long and 2 cm. wide (Plate XXVI, fig. 6) which matches so closely one of the figures of Newberry's *Populus cuneata*[48] that Newberry's figure might easily serve to illustrate. it It is not unlikely that immature leaves of a number of species of poplars, especially if preserved as fossils, would be impossible or at least extremely difficult to refer to the proper species. It is not at all improbable that some of the numerous fossil species of poplars represent such immature leaves, especially where the species have been described from scanty material.

### 10. **Populus smilacifolia** Newberry. (Plate XXVI, Fig. 4.)

*Populus smilacifolia* Newberry, Annals of the New York Lyceum of Natural History, IX, 1868, p. 66; *idem*, Illustrations of Cretaceous and Tertiary Plants, U. S. Geological Survey of the Territories, 1878, Pl. 14, fig. 5; *idem*, Later Extinct Floras of North America, U. S. Geological Survey, Monograph 35, 1898, pp. 53–54, Pl. 29, fig. 5.

The specimen is from "Locality 165," Missoula, and, although somewhat incomplete at the apex, it agrees very closely with Newberry's *Populus smilacifolia*, from the Fort Union group of North Dakota.

The single specimen shows a rounded-ovate leaf from the cordate base of which arise the midrib and two pairs of lateral veins, from the bases of the veins of the lower pair of these arising, however, a much fainter and very short pair, so that the leaf might be regarded as having three pairs of lateral veins. The lowermost strong pair of veins spreads widely from the base of the leaf, curving upwards to the margin at about half-way to the apex and sending off from the proximal side a few widely spreading veinlets which curve upwards towards the margin. The uppermost pair of veins, those next to the midrib, arise at a narrow angle with the midrib and, curving slightly forwards, reach the margin but slightly below the apex. In their upper two-thirds these veins give off short lateral branches, which curve out

[47] Heer, O. Flora Fossilis Arctica, I, 1868, p. 98.

[48] Newberry. The Later Extinct Floras of North America, U. S. Geological Survey, Monograph XXXV, 1898, Pl. 29, fig. 7.

and up towards the leaf-margin. So far as can be determined, the leaf-margin appears to be but very slightly serrulate.

*Populus smilacifolia* as described and figured by Newberry does not have the lowermost (third) pair of short and fine veins, as in the Missoula specimens, and it may be possible that the latter represent only a form of the common *Populus Zaddachi* Heer, the apex being but poorly preserved. The resemblance to *Populus smilacifolia* is so close, however, that the specimen has been provisionally referred to that species.

11. **Juglans pentagona** Jennings, sp. nov. (Plate XXIX, Figs. 1, 1*a*, 2, 2*a*.)

This species is based on the impression of a nearly complete leaflet about 6 cm. long by 4 cm. wide, broadly ovate, rather abruptly rounded to a bluntly acute apex, the base being apparently broadly rounded. The midvein is fairly strong; secondary veins, about thirteen pairs, varying from alternate to opposite, the lowermost arising from the midvein at a rather acute angle and then curving quickly outward to a course at almost right angles to the midvein, then curving upward toward the margin, the median and upper veins spreading from the midrib at an angle of 25–30° and curving gradually upward towards the margin. All the veins unite in wide camptodrome loops with the lower tertiaries from the next upper vein, these loops usually running to within a millimeter or two of the leaf-margin and giving off in turn finer loops reaching practically to the margin. The tertiaries from the median and upper secondaries, especially, leave the secondaries at right angles at distances of 2–4 mm. apart, forking and meeting in an alternate manner about midway between the secondary veins, so as to form approximately pentagonal areas. Within these meshes the finer veinlets form rather distinct polygonal meshes mainly about 0.3–0.7 mm. wide. The margin of the leaf is entire, but slightly undulate. The lowermost secondaries are considerably closer together than are the median and upper ones.

In another fragment of rock from this same locality is a leaflet which I take to represent the same species as that described above. It is 8 cm. long by 2.2 cm. wide, lanceolate, the base unequal, being rounded on the one side and tapering in almost a straight line on the other side, the apex being rather slenderly acuminate. The leaf-margin is entire. The midvein is strong, the secondaries being in about seventeen pairs, the lowermost leaving at an acute angle, then curving more widely, then again curving forwards towards the margin where they become camptodrome with tertiaries from the next upper secondary. The median and upper secondaries spread quite widely and towards the margin send off proximally strong tertiaries, or

they sometimes fork. Between these median and upper secondaries there are a few intermediate shorter secondaries, which sometimes curve around and loop with the main adjacent secondary at perhaps one-half to two-thirds of the distance from the midvein to the margin.

The wider impression, the first of the fossils just described, is taken as the type of the species, the specific name having been suggested by the more or less distinctly pentagonal areas formed by the tertiary veins. The specimens are from Douglass' "Locality 165," Missoula, and are associated in the same blocks with *Populus Zaddachi* Heer, *Betula multinervis* Jennings, *Sequoia Haydenii* (Lesquereux) Cockerell, and *Alnus Hollandiana* Jennings.

The genus *Juglans* has about twelve living species ranging from southeastern Europe to eastern Asia, and in North America from the temperate regions south to Mexico. The genus also occurs in the Andes of South America. About forty fossil species have been referred to the genus, beginning rather early in the cretaceous (Dakota, Magothy, Raritan beds), the number of species increasing to between twenty and thirty in the Eocene, a few in the Oligocene, about forty reported for the Miocene, and about thirty in the Pliocene. The genus was widely distributed over the northern hemisphere, especially during the Eocene, ranging from the southeastern part of the United States to the middle and northwestern United States, British Columbia, and Alaska. The distribution during the Miocene was apparently more southern (Florida, California, Brandon beds of Vermont, John Day beds of Oregon), no occurrences having been noted farther north in America than Oregon and Vermont.

*Juglans pentagona* is perhaps most nearly related among fossil plants to *Juglans crassifolia* Knowlton, common in the uppermost John Day beds[49] and regarded as probably Oligocene, and to *J. rugosa* Lesquereux, reported from the Laramie and Montana formations (Cretaceous) and, more recently by Knowlton[50] from the Eocene (Raton Formation) of Colorado and New Mexico.

12. **Betula multinervis** Jennings, sp. nov. (PLATE XXIV, FIG. 4; PLATE XXVII, FIGS. 1, 1*a*, 1*b*, 1*c*, 2; PLATE XXVIII, FIG. 2.)

The leaf-blades vary from 4–9 cm. long to 2.5–5 cm. wide, being lance-ovate to ovate-oblong or widely ovate, the petiole slender, about 1 cm. long, the leaf-base

[49] Knowlton. Fossil Flora of the John Day Basin, Oregon, U. S. Geological Survey, Bulletin CCIV, 1902, p. 36, Pl. 4, fig. 3.

[50] Knowlton. Fossil Floras of the Vermejo and Raton Formations of Colorado and New Mexico, U. S. Geological Survey, Professional Paper CI, 1917, p. 293, Pl. 112, fig. 4.

rounded or faintly subcordate, occasionally somewhat inequilateral, the apex slenderly acute to long acuminate, and the margin of the leaf sharply doubly serrate almost to the base. The tooth at the apex of each secondary vein appears larger than the intermediate teeth, because the leaf-margin slopes inward and backward from this tooth to a rather deep acute sinus in front of the next main tooth, the intermediate teeth being not much smaller than the main tooth, but situated successively lower down on the slope from it to the main sinus. The midrib and veins are deeply impressed on the dorsal surface of the leaf, the veins being usually in 15–16 pairs (13–18), close, almost straight, parallel; in the wider leaves giving off toward the margin from one to four strong branches, which swing down and run out into the intermediate teeth. The tertiary veins are rather prominent, mainly running straight across from one secondary vein to the other and forming nearly right angles with them, sometimes forking or irregularly anastomosing about halfway between them. On the upper surface of the leaf the deeply impressed character of the venation resembles the somewhat rugose surface, which occurs in some of the living species of *Ulmus*.

The fruits associated with the leaves and probably belonging to the same species, although not attached to the same twig with any of the leaves, occur only in "Locality 165," at Missoula. They are evidently narrowly oblong-cylindrical, about 5 mm. thick by 1.5 cm. long, the scales being about 4 mm. long, their three obtuse lobes reaching to about an equal height, the outer lobes about 0.8 mm. wide, ascending at an angle of about 40° from a rounded sinus, the median lobe being narrower. The main outline of the scale is basally rounded and then narrows rapidly to an acuminate tapering portion about 1 mm. long.

The puzzling similarity between the leaves of species of *Carpinus*, *Ostrya*, and *Betula* cannot but cause some uncertainty as to the generic position of the material. It is quite generally stated that the teeth of *Ostrya* are simple and somewhat smaller than are the more or less serrate teeth of *Carpinus*. The specimens show rather fine teeth, which, as far as could be determined from the specimens from Missoula can not be said to be serrate. Further, in the modern species of these genera *Carpinus* has little or no indication of branches running out from the lower side of the veins to form the secondary serrations, but this is quite characteristically the case in our modern *Ostrya virginiana*. The specimens from Missoula agree in this respect with *Ostrya*, rather than with *Carpinus*. However, this method of branching is also quite characteristic of some of the species of *Betula*, such as *Betula lenta* of eastern North America, and a careful comparison of the specimens before me with leaves of *Ostrya* and *Betula* reveals no diagnostic character by which the

fossil plant might be referred to one of these genera and not to the other. The disposition of the species under *Betula* practically rests only upon the fact that there were associated with the leaves some specimens of cones, which can be none other than those of *Betula*, and as there are no leaves of other species among the fossils which can be referred to *Betula*, it is assumed that the cones belong to the species, the leaves of which are so abundant in the rocks at that place.

Impressions of these leaves occur abundantly in the collections from both of the localities at Missoula, the most complete specimens being from "Locality 196." The fruits are represented only from "Locality 165."

The genus *Betula* is reported first in North America from the Dakota group in the Cretaceous, thence extending through the Montana and the Laramie into the Eocene, where it is represented by more than a dozen species. In the North American Miocene there are reported about a half-dozen species.

13. **Alnus Hollandiana** Jennings, sp. nov. (PLATE XXV, FIG. 3; PLATE XXIV, FIG. 8; PLATE XXVIII, FIG. 1; PLATE XXX, FIGS. 1, 1*a*, TYPE; fig. 3, CONES.)

The leaves are variable in size, the blades of the largest being about 12 cm. long by 5.5 cm. wide, elliptic to oval-elliptic, the apex being rather widely acute, the base acuminately narrowed into a slender petiole, which in one specimen reaches a length of 3.5 cm. The leaf-margins have small, low, somewhat crenate teeth, which are tipped with a glandular or at least a thickened point, the teeth disappearing along the basal 1–2 cm. of the margin. The midrib is rather strong, sending off from nine to twelve somewhat upwardly curved parallel veins, the uppermost of these more or less directly running out into the teeth, the greater number of them, however, curving a little and with branches looping in camptodrome fashion quite close to the margin and sending off minute branches which themselves terminate in the teeth. Usually the base of the secondary vein bends down slightly where it joins the midrib, thus forming a more acute angle. The tooth into which the vein runs, especially in the upper part of the blade, or which most closely approaches the vein in the lower part of the blade, is somewhat larger than the intermediate teeth, it having a height of 1–1.5 mm. There are three to five of these intermediate teeth between each pair of the main teeth. The veinlets (tertiaries), running across from one vein to the next, do so at about right angles to the veins and are rather far apart (about 2–4 mm.), the enclosed areas thus being approximately rectangular, and about two to three times as long as wide. The ultimate meshwork is relatively quite fine, most of the veinlets visibly having their ends free. The leaves

appear to have been rather thin but yet stiff, leathery, and especially on the lower side quite smooth and, perhaps, shining. The venation is impressed on the upper surface of the leaf, even the finest meshwork showing on some of the impressions. On the lower side of the leaf the venation is decidedly prominent, even to the finest meshwork.

In some of the specimens the veins in the upper part of the leaf run almost directly to the tooth, although sending off camptodromous branches towards the margin, the tip of the vein which runs out into the tooth often being reduced to a slender nervule not much stronger than those which run out into the intermediate teeth. In general shape and also in venation there is considerable resemblance to the terminal leaflet of some of the species of *Hicoria* and *Juglans*, but the resemblance to *Alnus*, such as *Alnus rhombifolia* Nuttall, of California, or even of some of the more acute leaves of forms of *Alnus rugosa* (DuRoi) Sprengel is closer. In size and in the acute outline of the base and apex the leaves are likewise very similar to those of the Mexican *Alnus glabrata* Fernald (*See* Pringle's *No. 8022*, from Tizapan, Mexico, 1899.)

The Missoula species is closely related to *Alnus carpinoides* Lesquereux from Bridge Creek, Oregon, (Upper Eocene), but differs in that the leaves are more oblong and less ovate than in the Oregon species. Practically the same characters distinguish the Missoula species from *Alnus serrulata fossilis* Newberry, also occurring in the deposits of Bridge Creek, Oregon. The lower part of the leaf in the Missoula specimens begins to narrow from about the middle of the blade and finally tapers quite accuminately to the petiole.

There is a fine series of leaf impressions of this species from Mr. Douglass' "Locality No. 196" and a few from "Locality 165," many of them fragmentary, but representing various sizes and considerable variation, principally with regard to the apex, this occasionally becoming blunter, especially among the smaller leaves. Among these smaller leaves it sometimes becomes difficult to make a satisfactory distinction between this species and the most acute forms among the larger leaves of *Alnus microdontoides* with which latter species *Alnus Hollandiana* is frequently associated in the same pieces of rock. Nevertheless, the majority of the specimens of the two species show clearly as much difference as would be found in a similar association of specimens of leaves from different species of living alders.

This fine species is named in honor of Dr. William J. Holland, Director of the Carnegie Museum, at whose request the study of the fossil plants from the Oligocene beds of volcanic dust at Missoula was undertaken and which has led to the preparation of this paper.

14. **Alnus microdontoides** Jennings, sp. nov. (PLATE XXIV, FIG. 7; PLATE XXX, FIGS. 2 and 2*a*, TYPE.)

The leaves are 3.5–8 cm. long, and 2–3 cm. wide, widest somewhat above the middle, the blade being narrowly obovate to broadly oblong-elliptic or even somewhat ovate, narrowed acutely to acuminately at the base, petioles slender, up to 13 mm. long, the apex widely rounded, the tip itself usually somewhat retuse varying to obtuse or rarely acutish. The midrib is strong and deeply impressed dorsally, ventrally standing out sharply and prominently. The secondaries are also impressed dorsally and prominent ventrally, springing from the midrib at an angle of about 45°, there being eight to eleven pairs, either alternate or opposite, evenly spaced, parallel and straight to near the margin, then curving slightly forward and usually ending in a tooth, but before doing so, branching and becoming very slender, the branches being few, springing from the lower side of the vein and curving out to the margin and there ending in teeth or variously anastomosing. The tertiaries are spaced about 1–3 mm. apart, rather strong, distinctly impressed above and prominent ventrally, springing from the secondaries at a wide angle and curving slightly outward and running across to the next secondary, or forking and joining with the forks of the adjacent secondary, the final meshwork being fine and indistinct. The margin of the leaf is minutely serrate, there being from two to four slightly smaller teeth between each pair of those teeth which terminate the secondary veins. The teeth are sharply glandular- or callus-tipped and are rather prominently directed forward.

In general appearance the leaves resemble rather closely the form of *Alnus rugosa* known as variety *serrulata* (Aiton) Winkel (*Alnus serrulata* Willdenow). They seem to bear much the same relation to this modern American plant that the similar and approximately contemporaneous *Alnus microdonta* Saporta, from the Armissan of southeastern France, bears to the modern Mediterranean *Alnus glutinosa* var. *denticulata* (Meyer) Ledebour (*Alnus oblonga* Willdenow). In the leaves of *Alnus microdontoides* the serrulations extend along the margins of the leaves to within a centimeter or less above the the base, considerably farther than Saporta figures for *Alnus microdonta*.[51]

As has been pointed out in Gray's Manual of Botany[52] there is considerable intergradation, in the northern part of the range of *Alnus rugosa*, between forms of that species and the equally variable *Alnus incana*, of somewhat more northern

[51] Saporta, G. Études sur la Végétation du Sud-est de la France a l'Epoque Tertiaire, Annales des Sciences Naturelles, Botanique, Ser. 5, IV, 1865, p. 110, Pl. 6, fig. 3.

[52] Gray, Asa. New Manual of Botany, Seventh Edition, 1908, p. 337.

range. Specimens referable to *Alnus rugosa* show a greater variability than is shown in the numerous leaf-impressions from the Missoula beds which I have referred to *Alnus microdontoides*. During the first part of my studies on these specimens the attempt was made to differentiate two species, one with a fairly evenly serrate oblong-elliptic leaf, with a blunt or retuse apex and an acuminately narrowed base, the other with a more plainly doubly serrate leaf, relatively wider, more acute at the apex and less acuminately narrowed at the base. Further studies of material later found in another box with a large number of intermediate specimens disclosed the fact that no separation of these extremes could be made other than in a purely arbitrary manner.

Beginning in the upper Cretaceous, the genus *Alnus* attained in the Miocene a general distribution through the arctic and northern North American and Eurasian regions. Altogether there have been described about forty fossil species, mostly from the Miocene, although in the western part of the United States a number of species have been reported from the Eocene, particularly from the Fort Union beds. There are now recognized about thirty living species, these ranging well over the northern hemisphere, and in America extending south to Peru.

15. **Quercus laurosimulans** Jennings, nom. nov. (Plate XXVIII, Fig. 3; Plate XXXI, Figs. 3 and 3*a*.)

*Quercus laurifolia* Newberry, Proceedings of the United States National Museum, V, 1883, p. 505; *idem*, The Later Extinct Floras of North America, U. S. Geological Survey, Monograph XXXV, 1898, p. 76, Pl. 59, Figs, 4 and 60, and Pl. 60, fig. 3. Not *Quercus laurifolia* Michaux, Histoire des Chênes de l'Amérique, 1801, No. 10, Pl. 17.

Newberry's original description is as follows:

"Leaves petioled, lanceolate, 6 inches in length by 1½ inches in width, equally narrowed to the point and petiole; margins entire or faintly toothed or undulate; nervation regular; midrib strong, straight, lateral branches, about ten pairs, arching gently upward, terminating in the margins".

The leaf-blade in the best Missoula specimen is between 10 and 11 cm. long, by 4 cm. wide, elliptic lanceolate, rather slenderly acuminate at both base and apex, and with a slender channeled petiole at least 2.5 cm. long, probably even longer. The midrib is strong, rather wide (about 1 mm.), flat, sunken in the dorsal surface of the leaf and sending off at wide angles about twelve pairs of slender but prominent veins, which curve upwards towards the margin where the attenuate ends run almost parallel to it and apparently form loops with the short branches from the next upper

vein. Between the main veins the midrib gives off also short but prominent intermediate veins forming practically right angles with it, these short veins forking and disappearing at a distance of 4–6 cm. from the midrib. The veinlets from the secondary veins are irregularly placed and form wide angles with the secondary veins and finally anastomose to form a rather coarse meshwork with irregular angles. The lowermost veins, even those in the attenuate base, leave the midrib at about the same wide angle as those in the middle of the leaf, running quickly out to the apparently slightly revolute margin. The margin is entire but slightly undulate in places. The venation is mostly rather deeply impressed on the dorsal surface of the leaf and prominent on the under surface. The extreme apex of the leaf is broken off in the fossils at hand.

The name *Quercus laurifolia* having been used at an earlier date by Michaux for the well-known Laurel Oak of the southeastern United States, it becomes necessary to rename Newberry's Tertiary species. The names *laurina, laurifolia, laurophylla, lauriformis* and *lauroides* having been used for various species of fossil or living oaks with leaves resembling those of some of the *Lauraceæ*, I have chosen the name *laurosimulans* in order to preserve as nearly as possible the meaning of the name used by Newberry for the fossil species.

The specimen first studied was referred to *Laurus* but further study led to a decision in favor of *Quercus*. My reasons for referring the specimen to *Quercus* rather than to *Laurus* are as follows: The rather numerous and prominent but *short* veins given off from the midrib between the larger main veins and at approximately right angles to the midrib; the rather strong branching and camptodromous looping of the outer ends of the veins; the veins in the attenuate base of the leaf leaving the midrib at practically the same angle as those in the middle and upper parts of the leaf; the impressed, but rather flat, dorsal surface of the midrib; and the slenderer petiole.

The general outline of the leaf is very close, indeed, to that of *Laurus princeps* Lesquereux, as figured from Corral Hollow, California. The resemblance to other species of the *Lauraceæ*, such as *Nectandra*, is striking, as is also the resemblance to the leaves of some of the living species of the *Myrsinaceæ*, such as *Ardisia, Icacorea*, and *Myrsine*, but in these genera the midrib does not usually give off the short intermediate veins such as appear so prominently in the Missoula specimens, or, if present in the *Myrsinaceæ*, they are not at all prominent and, further, the petioles are almost invariably quite short.

Newberry's *Quercus laurifolia* was described from specimens obtained from "Burned shales over lignite beds, Fort Berthold, Dakota," now regarded as Fort

Union in age[53] (Eocene), thus not more distant from the Oligocene than many other closely related species in the Tertiary.

About two hundred fossil species of oaks have been described, beginning in the Cretaceous, during which period the genus was widely distributed in western Europe, the United States, and in Greenland. In the Tertiary the genus occurred in Australia and quite abundantly in the northern hemisphere, in what are now temperate regions, as well as farther north in Greenland and Alaska. In North America oaks were particularly abundant in the Dakota and up through the Eocene and Miocene, and in Europe they appear to have reached their maximum in the Oligocene and Miocene.

Oaks with entire margins appear from the evidence thus far furnished by fossils to have been relatively more numerous in the Tertiary than at the present time. In the Oligocene and Miocene there have been reported as oaks with entire margins at least the following: *Quercus neriifolia* A. Braun, *Q. elæna* Unger, *Q. Lyelli* Heer, *Q. chlorophylla* Unger, *Q. Daphnes* Unger, *Q. elæomorpha* Saporta, *Q. lauriformis* Saporta, *Q. socia* Saporta, *Q. areolata* Saporta, *Q. elliptica* Saporta, and *Q. simulata* Knowlton.

16. **Quercus flexuosa** Newberry. (Plate XXXI, Figs. 1 and 1*a*.)

*Quercus flexuosa* Newberry, Boston Journal of Natural History, VII, 1863, p. 521; *idem*, The Later Extinct Floras of North America, U. S. Geological Survey, Monograph XXXV, 1898, p. 74, Pl. 19, figs. 4–6.

The single specimen consists of the impression of part of a leaf, the base and apex being missing. The impression shows the leaf to have been somewhat curved and about 9 cm. long by 3.5 cm. wide, narrowly elliptic oblong, the basal portion evidently narrowing inequilaterally. The margin has a few unequally spaced, sharp, small teeth, these being directed forwards. The midrib is strong, the secondaries fairly so, alternate, spaced about 5–9 mm. apart, arising at a wide angle and swinging forwards, being branched towards the margin of the leaf and these branches anastomosing in camptodrome fashion. Between the secondaries the midrib sends off fine veins which anastomose with fine veins or their branches from the secondaries, the meshes thus formed being polygonal, with the sharper angles and the longest dimension directed at about right angles to the midrib.

The specimen matches Newberry's figures very closely as to size, outline, and venation, although the inequilateral outlines in both Newberry's figures and in

[53] Merrill, G. P. Catalogue of the Type and Figured Specimens of Fossils, Minerals, Rocks, and Ores. Part II. Bulletin of the United States National Museum, LIII, Part II, 1907, p. 283.

the Missoula specimen suggests that the impressions may perhaps represent leaflets of a compound leaf rather than a leaf of *Quercus*.

Newberry's specimens were from near Bellingham, Washington, in rocks of the Puget Sound group, thus possibly Oligocene, so that the species may have had a general range over the region now separated into two floral regions by the Cascade Mountains. The Missoula specimen was from Douglass' "Locality 165" and was accompanied in the same block by *Betula multinervis* and *Sequoia Haydenii*.

17. **Quercus approximata** Jennings, sp. nov. (PLATE XXVII, FIGS. 3 and 3*a*, TYPE.)

The specimen consists of an impression about 6 cm. long from an oblong leaf of a maximum width of 2.8 cm., the basal portion of the leaf being missing. The leaf was pinnately veined, the midrib and secondaries being quite prominent, the secondaries arising from the midrib about 7–11 cm. apart, but forming with the midrib angles of but 20–30 degrees. Some of the veins are a little more widely diverging at the very base, but immediately above this the veins all pursue straight and parallel courses to the margin, where they end in rather low but sharply crenate or forwardly-directed and evidently often slenderly spine-tipped teeth. Along the margin of the leaf, between each pair of the main teeth, are from one to four, usually two or three, similar teeth of about the same size as the main teeth. These intermediate teeth are at the ends of fine tertiaries which swing off from the lower side of the next upper secondary vein. On the specimen at hand one of the secondary veins is strongly but acutely forked at about two-thirds of the distance from the midrib to the margin of the leaf. The leaf was evidently distinctly leathery in texture, the impression showing a smoothish surface on which the tertiary veins are almost indistinguishable, being obscured by the very fine but unusually distinct ultimate meshwork.

The specimen is from "Locality 196," Missoula, associated in the same piece of rock with fragments of two other leaves of probably the same species, and also with *Betula multinervis*.

The species is nearly related to *Quercus furcinervis americana* Knowlton, reported from the Miocene of the Yellowstone National Park (Lamar) and also from the Eocene of the John Day beds of Oregon (Cherry Creek), and is perhaps about as closely related to the following species reported by Heer from Greenland: *Q. Olafseni* Heer, *Q. platania* Heer, *Q. Steenstrupiana* Heer, and *Q. furcinervis* Rossmæssler. The species from Missoula differs from all of these, however, in the much narrower angle between the secondary nerves and the midrib, and also in that its tertiary veins are so much more obscure. The species clearly belongs to

the Chestnut-oak group, the straight, parallel, rather closely pinnate secondary nerves, as well as the character of the teeth and the firm reticulate surface of the leaf, all suggesting *Castanea*.

The specific name "*approximata*" has been used for this species because of the short distance between the secondary veins, this feature being due to the relatively narrow angles formed by the secondaries with the midrib.

18. **Ficus** (?) **prunifolia** Jennings, sp. nov. (Plate XXXII, Fig. 1 and 1*a*, TYPE.)

The specimen consists of the impression from a piece about 7 cm. long from the middle of a leaf about 7 cm. wide, pinnately veined, the secondaries being spaced about 3–13 cm. apart, given off from the midrib at an angle of 50–55° and curving gradually forward, in the outer part giving off strong branches which loop in camptodromous fashion with the curved and attenuate end of the next lower secondary. From the midrib and from the lower side of the secondaries are given off numerous fine but distinct veins, which pursue a course almost at right angles to the midrib, and fork and anastomose to form polygonal, often diamond-shaped, areas, the sharper angles and longest dimension of which lie cross-wise to the leaf. Smaller and weaker camptodromous loops are formed closer to the leaf-margin by branches from the main loops. So far as preserved the leaf-margin appears to be entire, or at the most but slightly undulate. The venation appears to have been rather deeply impressed and in texture the leaf was probably rather thick.

The specimen came from "Locality 196," Missoula, and is on the same piece of rock with impressions of *Betula multinervis* and *Alnus Hollandiana*. The generic position of the species has been the cause of much perplexity. The rather striking crosswise trend of the finer veins and their meshes is suggestive of species of *Ficus*, *Diospyros*, *Terminalia*, various genera of the *Ebenaceæ*, *Lauraceæ*, and other plants, but most of all, perhaps, it is suggestive of some of the larger leaved-species of *Prunus*, such as *P. alabamensis* Mohr. This resemblance to *Prunus*, however, is not so close, when the outermost course of the veins and the character of the leaf-margin are also taken into account, so that the species seems best referred to the genus *Ficus*.

In *Ficus* there have been reported probably between two and three hundred fossil species, beginning well down in the Cretaceous, thirty or more being reported from the Dakota of the western part of the United States. During the Cretaceous the genus was widely distributed, species being reported from Greenland, Europe, North America, Australia, and New Zealand. In the Eocene there are about as many reported, fifty or more; sixty or more from the Oligocene, mainly in western

Europe; while about ninety species are reported for the Miocene, about twenty of these being from the United States, and about twenty are reported from the Pliocene. The range of the genus has been extended by reports of its discovery in Africa from the Oligocene and in Asia from the Miocene.[54]

19. **Ilex furcinervis** Jennings, sp. nov. (PLATE XXIV, FIG. 5, and PLATE XXXII, FIGS. 2, 2*a*, and 2*b*, TYPE.)

The extreme apex and base of the leaf is lacking in our specimen. The impression shows the leaf to have been obovate, probably about 8 cm. long, about 4 cm. wide, at the widest point, somewhat above the middle, narrowing rather rapidly towards the base, apparently rounded or at least narrowing very rapidly towards the apex. Margin entire in the lower half of the leaf, serrulate above, the teeth being widely triangular, about 0.5 mm. high, sharply callus-tipped, this tip directed forward and in the fossil showing a reddish-brown color. Midrib prominent, sending off about twelve pairs of rather prominent and mostly alternate veins, which leave at an angle of about 55–60 degrees, rather irregularly spaced, slightly curving upward, forking in their upper two-thirds or three-fourths, these forks themselves forking and their branches meeting to form irregularly diamond-shaped areas extending to within 1–3 mm. of the leaf-margin. From the outer ends of these diamond-shaped areas one or usually two nervules diverge, again forking and looping in camptodromous fashion or disappearing into the minute teeth. Usually it is the upper one of the two nervules leaving the apex of an area which runs out into the tooth. In the middle of the leaf the tertiaries and the minute ultimate meshwork are faint, suggesting that they were embedded in the tissue of a thick leaf and are apparently rather irregular. The leaves were evidently not only thickish but coriaceous and smooth.

In general outline the leaf was not unlike the wider leaves to be found on vigorous shoots of our living southern *Ilex Cassine* Linnæus, and it also resembles to a certain extent *Ilex longifolia* Heer,[55] both in venation and in that the margin is toothed above. The general aspect of the leaf is that of the more obovate leaves of *Quercus imbricaria* Michaux, our modern Shingle-oak, and there are resemblances also to *Quercus furcinervis americana* Knowlton, reported for the Eocene and Miocene.

The genus *Ilex* contains about 275 living species, mostly in North and South America and temperate and tropical Asia, a few occuring also in Africa, Australia,

[54] Berry, E. W. The Lower Eocene Floras of the Southeastern North America, U. S. Geological Survey, Professional Paper XCI, 1916, pp. 82–83.

[55] Heer, O. Flora Fossilis Arctica, I, 1868, p. 124, Pl. 48, figs. 3–6.

and Europe. More than one hundred fossil species have been reported, thirteen or more of these having been accredited to the Upper Cretaceous from North America, Greenland, and western Europe, and about fourteen in the Eocene from the eastern and western United States, Alaska, Greenland, and western Europe. There are twenty or more species reported for the Oligocene and more than fifty for the Miocene.[56] The occurence of *Ilex* in the Oligocene in the region of Missoula is thus rather to be expected than otherwise.

The specimen in the collections of the Carnegie Museum consists of the obverse and reverse impressions of a single leaf and it was found at "Locality 196", Missoula. The specific name *furcinervis* has been chosen to indicate, as in the case of *Quercus furcinervis*, the characteristic strikingly forked branching of the secondary veins.

20. **Celastrus parvifolius** Jennings, sp. nov. (Plate XXXI, Figs. 2 and 2*a*, Type.)

The single specimen shows an oblong-ovate leaf 11 mm. wide and evidently about 3 cm. long, the apex being broken away. The base of the leaf narrows evenly and rather acutely, being apparently sessile, but this latter feature can not be stated definitely. The leaf is pinnately veined, the midrib being fairly strong, the secondary veins being irregularly spaced, about four of them on each side of the midrib, from which they spring at an angle of about 45 degrees. The secondary veins curve gradually forward to near the margin of the leaf where they merge into a series of camptodromous loops with branches from the next upper secondary vein. The finer veins are quite irregular in spacing and direction, thus giving rise to an irregular, although somewhat coarse meshwork. The leaf-margin, with the exception of that of the cuneate base of the leaf, is rather finely serrulate with low teeth, directed somewhat forward, there being usually a fine vein extending into each of these teeth from the marginal camptodromous loops. The shape of the upper part of the specimen suggests a rather slenderly tapering apex.

The specimen is from "Locality 196," Missoula, and it perhaps most nearly resembles *Celastrus fraxinifolius* Lesquereux, from Florissant, Colorado (Miocene), and *C. Lindgreni* Knowlton, from the Payette of Idaho (Upper Eocene), although it is smaller than either of these. The generic position is none too certain, the leaf being suggestive of genera of the *Rosaceæ*, *Leguminosæ*, *Rhamnaceæ*, and *Ericaceæ*. Considering altogether the characters of leaf-margin, outline, and venation, particularly the method of looping and the finer meshwork, it seems best to refer the plant to *Celastrus*.

[56] See Berry, E. W. The Lower Eocene Floras of Southeastern North America, U. S. Geological Survey, Professional Paper XCI, 1916, pp. 104–105.

The genus *Celastrus* now contains over thirty species of shrubs, ranging through southern and eastern Asia to Australia and America, mostly confined to warm climates. The oldest known species (*Celastrus arctica* Heer) is reported from the Cretaceous (Raritan and Magothy of New Jersey and Maryland, and the Patoot of Greenland). About thirty species are reported from the Eocene, ranging over England, the eastern and western United States, Alaska, and Greenland. About the same number are reported from the Oligocene, evidently all European, and fifty or more are reported from the Miocene of the United States (Virginia, Colorado, Idaho, and Oregon), Europe, Asia, and Australia. Perhaps a dozen Pliocene species are known.[57]

It is interesting to note in this connection that no species of *Celastrus* has been reported heretofore from the Oligocene of America and that the geographically nearest locality for the occurence of *Celastrus* in other horizons is that of the nearly related *Celastrus Lindgreni* Knowlton in the Payette formation of western Idaho, probably of late Eocene age.

### 21. **Acer oregonianum** Knowlton. (Plate XXXII, Fig. 3.)

*Acer*, fruits of, Lesquereux, Proceedings of the U. S. National Museum, XI, 1888, p. 15, Pl. 6, figs. 2 and 3.

*Acer oregonianum* Knowlton, Fossil Flora of the John Day Basin, Oregon, U. S. Geological Survey, Bulletin CCIV, 1902, p. 75, Pl. 13, figs. 5–8.

Knowlton, *l.c.*, says of this species: "Fruits long and broad-winged, the axis being evidently very thick and provided with numerous strong veins; nucleus large, round, showing broad truncation where attached to the sister-fruit. . . . They range in length from 3.5–4.5 cm. The wing is unusually broad, being not infrequently 1.75 cm. wide. It is filled with numerous strong veins which are given off from the axis of the fruit in groups or bundles. . . . Abundant in Mascall beds at Van Horn's ranch and vicinity."

The Missoula specimen consists of a part of a fruit, comprising the upper part of the seed and a little more than 2 cm. of the wing. The bundles of strong veins given off from the seed are quite prominent, these opening out into the membrane of the wing at about right angles to the axis of the wing and forking from one to three times. The widest part of the wing is about 14 mm.

This specimen is from "Locality 165," Missoula. As Knowlton has pointed out, the fruit is very close to that of the modern *Acer macrophyllum* Pursh, found

[57] See Berry, E. W. The Lower Eocene Floras of Southeastern North America, U. S. Geological Survey, Professional Paper XCI, 1916, p. 105.

in the coastal region from Alaska to California, and now the only large native maple-tree west of the Rocky Mountain region.

*Acer* now comprises about one hundred and twenty species, in the northern hemisphere, mainly in temperate regions. Reports of the occurrence of the genus in the Cretaceous are perhaps rather doubtful. More definite are the reports of its occurrence in the Eocene (England), while in the Oligocene various species occurred in widely separated regions: Spitzbergen and southward in Europe to the Mediterranean, Greenland, Alaska, and in the western United States. During the Oligocene and Miocene the species were especially numerous in western and central Europe.

22. **Aralia longipetiolata** Jennings, sp. nov. (Plate XXXIII, Figs. 1, 1*a*, 2, 2*a*, Type.)

The material from "Locality 139," near Winston, Montana, contains numerous fragmentary leaf-impressions, of which a number show the leaf-base and petiole, but none of them show the complete apex. Although quite variable, the impressions apparently all represent a species of *Aralia*.

The leaves were lance-ovate to oblong-ovate, reaching a length of 7 cm. or more, the width being about half that amount. The petioles were slender, the longest ones preserved being about as long as the leaves were wide. The leaf was rather distantly pinnately veined, the secondaries being mostly six to eight on each side of the midrib, the lowest opposite or essentially so, the median and upper usually alternate. The veins form an angle of about 45 degrees with the midrib, then curve gently forward, one occasionally forking in the outer third. The secondaries are usually simple, but well out towards the margin they throw off at wide angles from one to three tertiary veins, which curve around and, like the attenuate tip of the secondary, end in low teeth, which are either sharply directed forward or else are broadly rounded-crenate. The leaf-base was equally or sometimes unequally broadly rounded and shallowly cordate, most of the leaves having one or two pairs of smaller more widely spreading secondary veins crowded into the space below the lowest main pair of secondaries. The appearance is almost that of a sub-peltate leaf, remotely suggesting leaves such as those described at various times under the names of *Credneria*, *Aspidiophyllum*, and *Protophyllum*. The tertiary veins are weak, rather closely spaced, and diverge from the secondaries and from the midrib at almost right angles. They mostly fork and join midway between the secondaries to form roughly pentagonal areas which are one to two times as high as wide. As far as can be determined from the specimens, the apex

was acute or perhaps even slenderly acuminate. The impressions indicate that the texture of the leaf was thin, like that of a shade-leaf.

Most of the fossil species of *Aralia* described have been of the type having palmate veins and lobes, or else being palmately compound, but the Winston species so closely resembles the modern *Aralia racemosa* L., that the writer has little hesitation in referring it to the genus *Aralia*.

Broadly rounded crenate teeth, such as occur on the margin of a few of the Winston fossils, are sparingly found in the modern *Aralia racemosa*, which rather regularly has the petiole long and slender, the base unequal, the basal secondary veins peculiarly crowded, and the leaf-blades thin, while the pattern of the venation, too, is much like that of the Winston fossils.

Although I can find no records of fossil Aralias very closely related to the species from the Oligocene of Missoula, yet the present distribution of *Aralia racemosa*, native to eastern North America, and closely allied species, such as *A. cordata* Thunberg of Japan, and *A. cachemirica* Decaisne of the Himalayas, argues for a Tertiary distribution of one or more ancestral forms of that type.

The genus *Aralia* now includes about thirty species of herbs and woody plants ranging through temperate North America and Asia, and south from the latter through the Malay Archipelago and into Australia. Many of the fossil species so reported are perhaps not *Aralia*, but belong to other genera of that family or even to other families. However, taking the reports as they stand at the present time, there are numerous species of *Aralia* described from the Cretaceous, perhaps sixty altogether, beginning in the upper part of the Lower Cretaceous in Portugal (Albian) and the eastern United States, and becoming numerous and practically cosmopolitan in the Upper Cretaceous. From the Eocene about twenty-five species have been described, these being most numerous in the Fort Union of the western United States and in the Paleocene of Belgium, while about an equal number have been described from the Oligocene, all European, and more than half of these are from the Sannoisian of southeastern France. About twenty-five species are recorded from the Miocene, distributed through North America, Eurasia, and Australia.[58]

Various species of *Aralia* having been recorded for the western part of the United States from the Eocene and Miocene, it is to be expected that Oligocene strata would also yield them from that region and, even though no closely related forms may have been recorded from the Eocene or Miocene of the West, yet the present

[58] See Berry, E. W. Aralia in American Paleobotany. Botanical Gazette, XXXVI, 1903, pp. 421–428; *idem*, The Lower Eocene Floras of Southeastern North America, U. S. Geological Survey, Professional Paper XCI, 1916, pp. 122–123.

distribution of *Aralia racemosa* and its allies would indicate that ancestral forms of that species existed in the region, so that their occurrence in the Oligocene of the Missoula district would be quite natural.

As the type specimen upon which this species rests I would designate the specimen shown on Plate XXXIII, figs. 2 and 2*a*.

23. **Vaccinium palæocorymbosum** Jennings, sp. nov. (Plate XXXIII, Figs. 3 and 3*a*, Type, and 4, 4*a*.)

The type specimen consists of an impression of a leaf with the apex broken off. The petiole is about 0.7 mm. in diameter, 4 mm. long, curved, uniform throughout its length. The leaf-blade is ovate-lanceolate, widest at about the middle, where it is 1.8 mm. wide, apparently about 4.5–5 cm. long, rather bluntly tapering towards the petiole, somewhat more narrowly tapering toward the apex; the margins entire, slightly revolute. The midrib is rather strong, tapering above, the secondary veins pinnate in probably about eight approximate pairs (six pairs are preserved in the specimen), these veins spreading at an angle of about 50° with the midrib, curving upward towards the margin and finally looping successively with branches from the lower side of the next vein above. The tertiary venation is fine and rather indistinct, but toward the margin and along the lower side of the lowermost pair of veins forming small narrow loops, while between the veins there are a few tertiaries running across from one vein to the other at almost right angles to them, the final meshes in the interior of the blade being rather small and indistinct. There appears to be a very narrow decurrent flange along each side of the petiole throughout its length.

In size, shape, and venation the specimen almost exactly matches leaves which can be selected from the modern *Vaccinum corymbosum* Linnæus of swamps and low woods from Maine, Quebec, and Minnesota to Virginia and Louisiana, about the only noticeable difference being the somewhat larger angle of divergence of the veins in the fossil specimen. In length of petiole, number and spacing of the veins, narrow loops on the lower side of the lowest pair of veins, revolute margin, margined petiole, etc., the resemblance is too close to be ignored. At first glance the fossil suggests *Quercus cinereoides* Lesquereux[59] but in that species the base is more rounded, the venation does not match that of the Missoula specimen very closely, and there is little basis for believing that an oak would have such a margined petiole.

[59] Lesquereux, Leo. The Tertiary Flora, U. S. Geological Survey of the Territories, VII, 1878, p. 152, Pl. 21, fig. 6.

The genus *Vaccinium* now contains about 130 species and it ranges from the Arctic Circle to the mountains of the tropics, having its greatest development in the Himalaya Mountains and in North America. Considerable doubt has been expressed as to the correct identification of some of the fossil forms reported, but it seems fairly certain that the genus is correctly ascribed to the Eocene, with three or four species from Alaska and Colorado, while in western Europe in the Oligocene and, especially, in the Miocene, the genus was represented by a number of species, so that the occurrence of *Vaccinium* in the Missoula region in the Oligocene would not be unexpected.

## EXPLANATION OF PLATE XXII.

Fig. 1. Buds of *Equisetum* sp. Enlarged two and one-half diameters.

Fig. 2. *Equisetum insculptum* Jennings. Type. Enlarged two and one-half diameters.

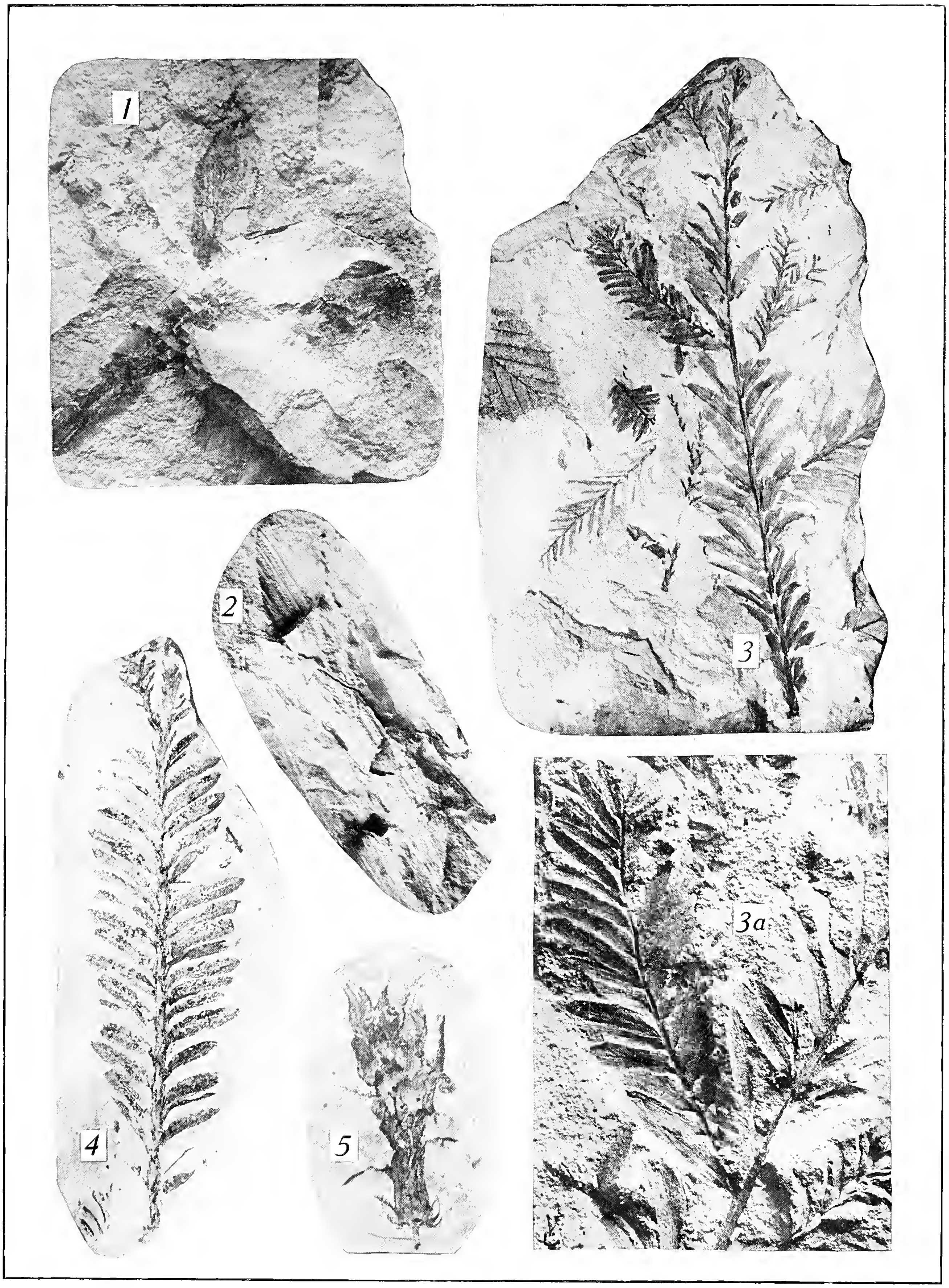
Fig. 3. *Sequoia Haydenii* (Lesquereux) Cockerell. Natural size.

Fig. 3*a*. The upper part of the same specimen, enlarged two and one-half diameters.

Fig. 4. *Sequoia Haydenii* (Lesquereux) Cockerell. Enlarged about two diameters.

Fig. 5. *Sequoia Haydenii* (Lesquereux) Cockerell. A young shoot enlarged three and one-half diameters.

All photographed from specimens in the Carnegie Museum collected by Earl Douglass from Montana. Figs. 1 and 2 from "Locality 139," Winston; Figs. 3–5 from "Locality 196," near Missoula, Montana.




*Equisetum* and *Sequoia*.

(For explanation see opposite page.)

## EXPLANATION OF PLATE XXIII.

Fig. 1. *Sequoia oblongifolia* Jennings. Type, enlarged about one and three-fourths diameter.

Fig. 1*a*. Part of same branch, enlarged two and one-half diameters.

Fig. 2. *Sabina linguæfolia* (Lesquereux) Cockerell. Enlarged about two and one-half diameters.

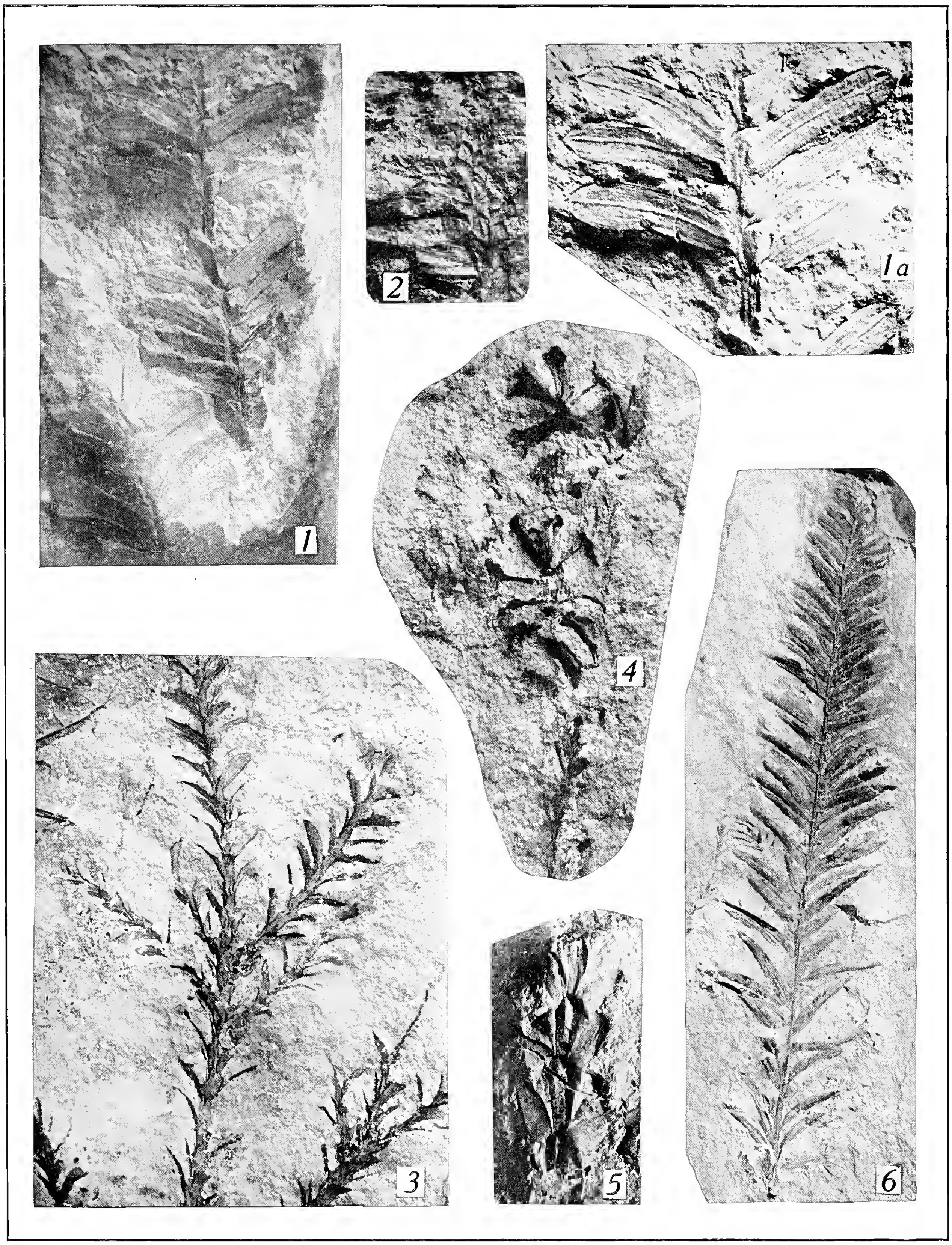
Fig. 3. *Sequoia Haydenii* (Lesquereux) Cockerell. Enlarged two and one-half diameters.

Fig. 4. *Sequoia Haydenii* (Lesquereux) Cockerell. Cones, enlarged about three and one-half diameters.

Fig. 5. *Thuyopsis gracilis* Heer. Enlarged about three and one-half diameters.

Fig. 6. *Sequoia Haydenii* (Lesquereux) Cockerell. Natural size.

Photographed from specimens in the Carnegie Museum collected by Earl Douglass from "Locality 196," Missoula, Montana.




*Sequoia*, *Sabina*, and *Thuyopsis*.

(For explanation see opposite page.)

## EXPLANATION OF PLATE XXIV.

FIGS. 1, 2, AND 3. *Sequoia Haydenii* (Lesquereux) Cockerell. Different types of leaves of the same species.

FIG. 4. *Betula multinervis* Jennings.

FIG. 5. *Ilex furcinervis* Jennings.

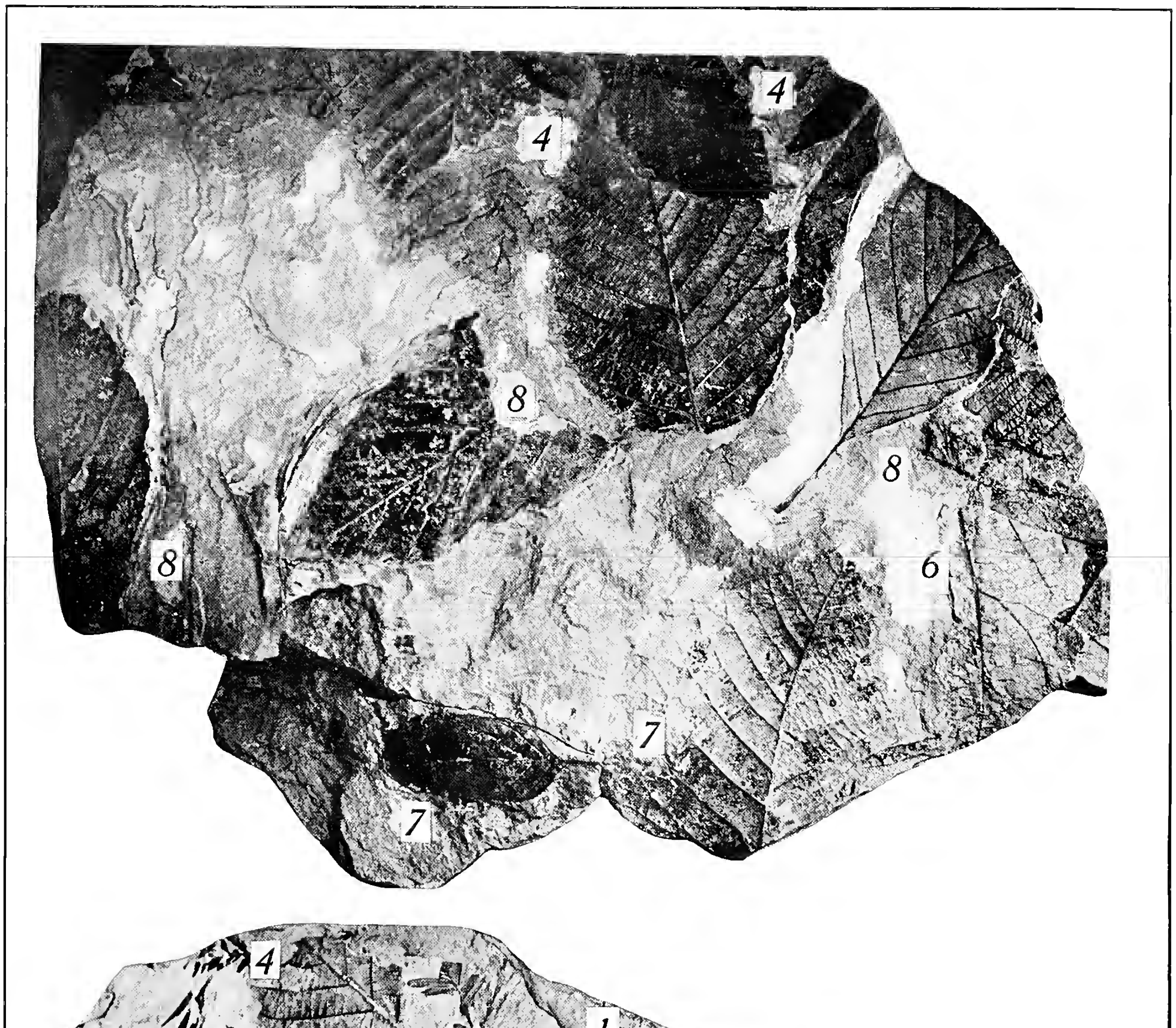
Photographed from a specimen in the Carnegie Museum collected at Missoula, Montana, from "Locality 196". About seven-eighths diameter.

FIG. 6. *Populus Zaddachi* Heer.

FIG. 7. *Alnus microdontoides* Jennings.

FIG. 8. *Alnus Hollandiana* Jennings.

Photographed from a specimen in the Carnegie Museum, collected at "Locality 196," Missoula, Montana, by Earl Douglass. About four-fifths diameter.




*Sequoia, Betula, Ilex, Populus,* and *Alnus.*

(For explanation see opposite page.)

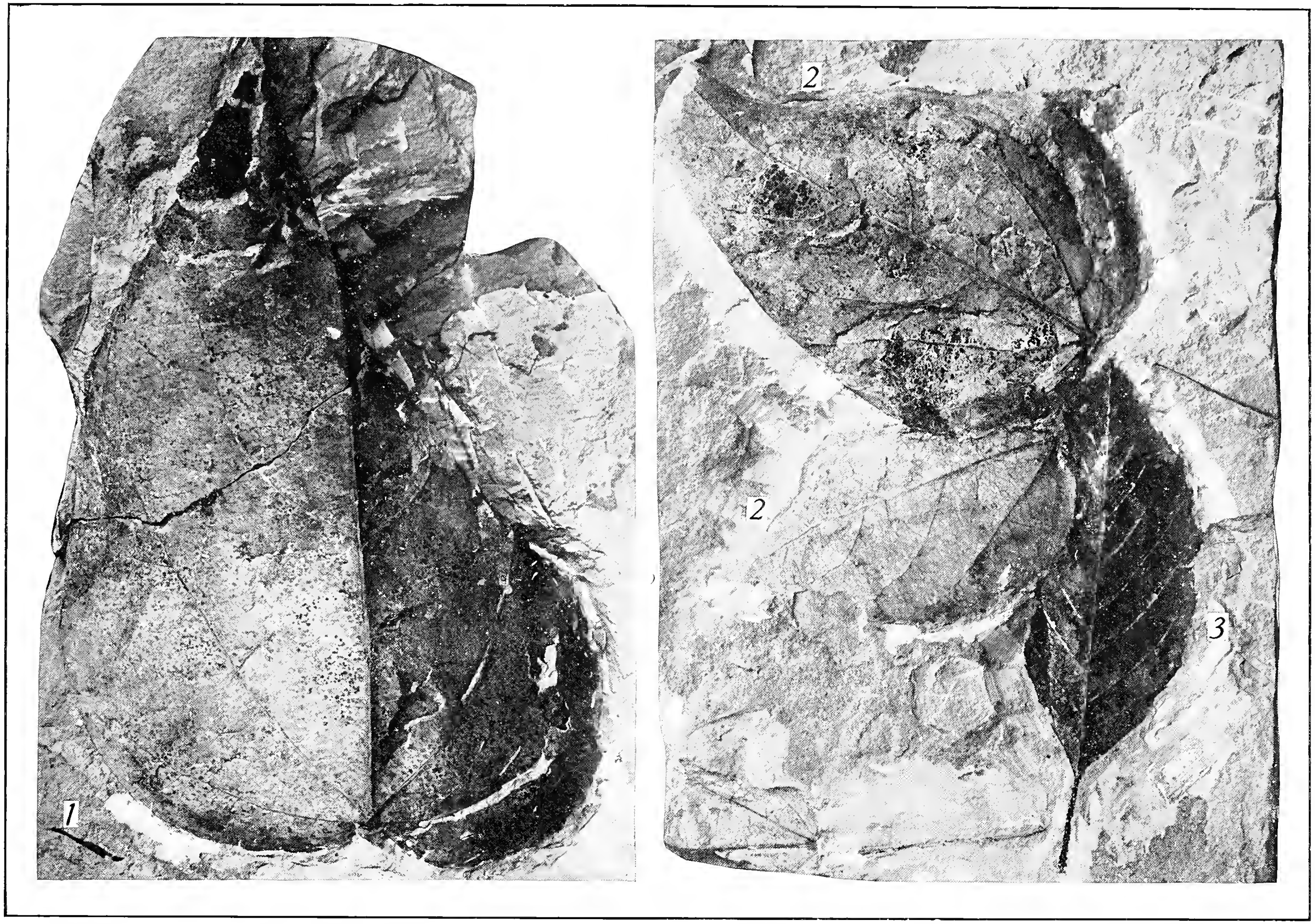
## EXPLANATION OF PLATE XXV.

Fig. 1. *Populus Zaddachi* Heer. Natural size.

Fig. 2. *Populus Zaddachi* Heer. About seven-eighths diameter.

Fig. 3. *Alnus Hollandiana* Jennings. Type. About seven-eighths diameter.

Photographed from specimens in the Carnegie Museum, collected at "Locality 196," Missoula, Montana, by Earl Douglass.




*Populus* and *Alnus*.

(For explanation see opposite page.)

## EXPLANATION OF PLATE XXVI.

FIG. 1. *Populus Zaddachi* Heer. Natural size.

FIG. 1*a*. Middle left-hand margin of same specimen, enlarged two and one-half diameters.

FIG. 2. *Populus Zaddachi* Heer. Natural size.

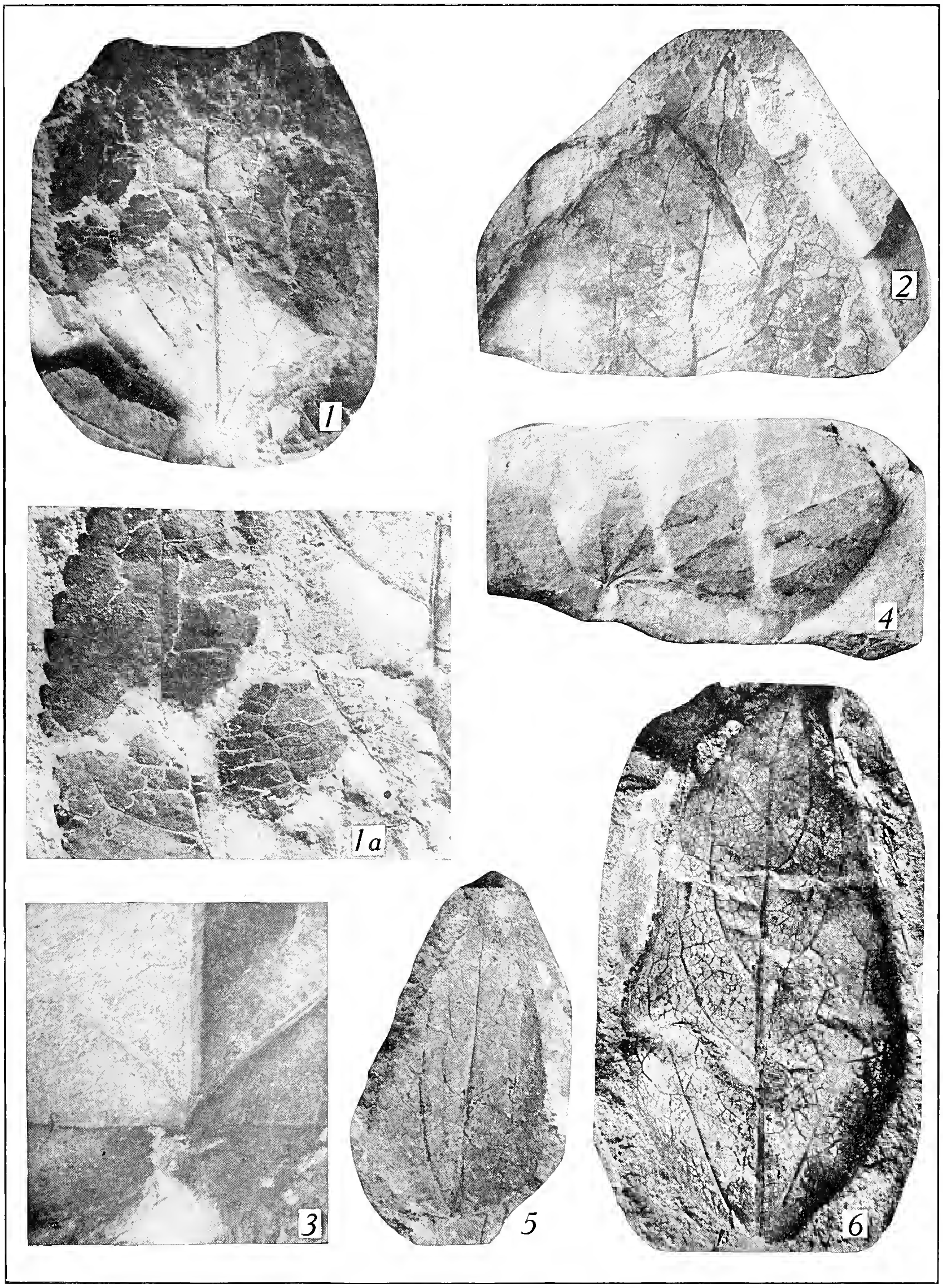
FIG. 3. *Populus Zaddachi* Heer. Base of leaf shown in Plate XXV, Fig. 1, enlarged two and one-half diameters.

FIG. 4. *Populus smilacifolia* Newberry. Natural size.

FIG. 5. *Populus Zaddachi* Heer. Natural size.

FIG. 6. *Populus Zaddachi* Heer. Another leaf enlarged two and one-half diameters.

All photographed from specimens in the Carnegie Museum collected by Earl Douglass at Missoula, Montana.—Figs. 1, 2, and 3 from "Locality 196;" Figs. 4, 5, and 6 from "Locality 165."




*Populus Zaddachi* and *P. smilacifolia*.

(For explanation see opposite page.)

## EXPLANATION OF PLATE XXVII.

Fig. 1. *Betula multinervis* Jennings. About three-fifths diameter.

Fig. 1*a*. Same specimen, natural size. Type.

Fig. 1*b*. Part of "1*a*," enlarged two and one-half diameters.

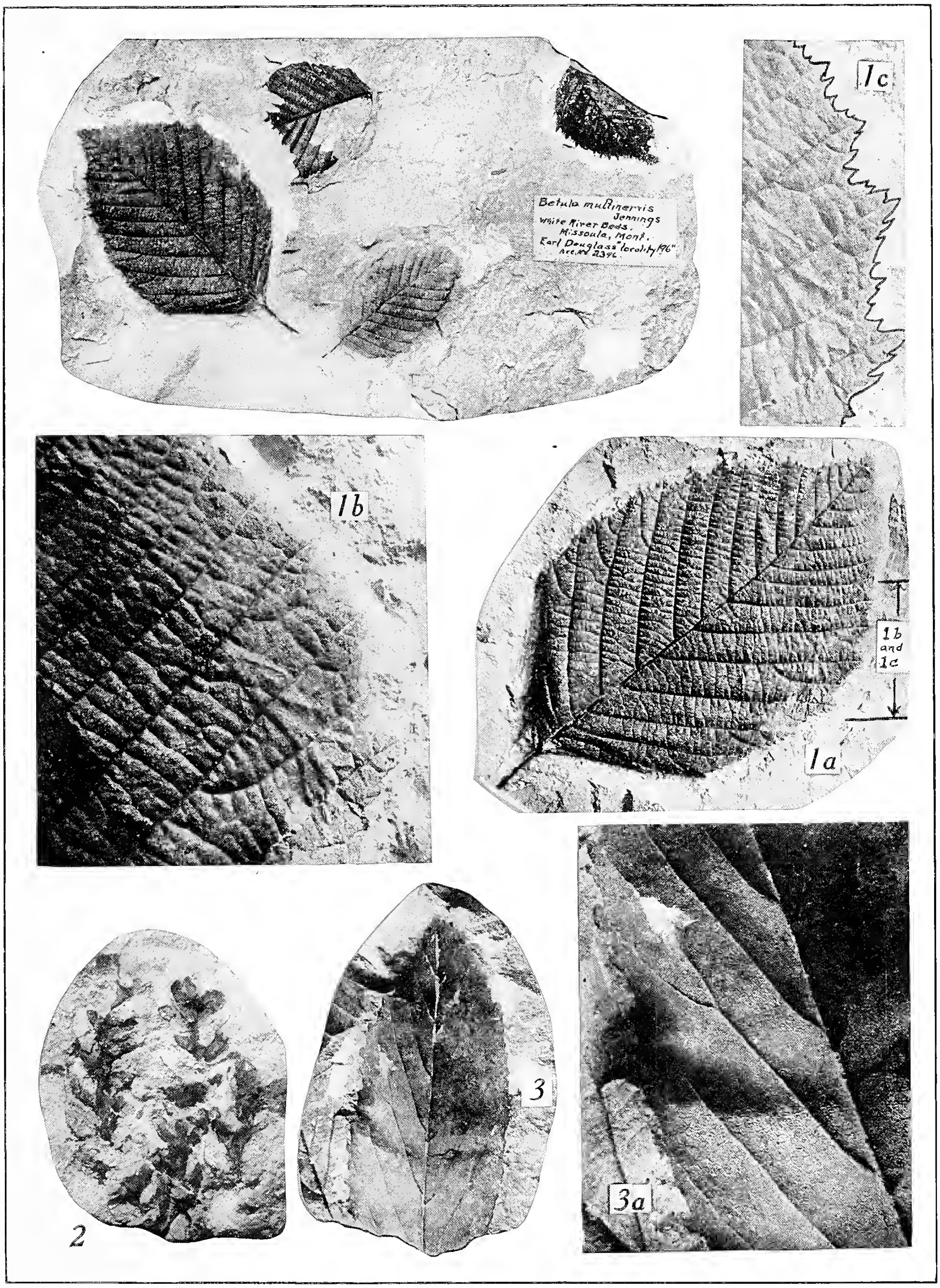
Fig. 1*c*. Same as "1*b*," with the margin of the leaf drawn in.

Fig. 2. *Betula multinervis* Jennings. Cones, enlarged about two and one-half diameters.

Fig. 3. *Quercus approximata* Jennings. Type. Natural size.

Fig. 3*a*. Part of the same specimen, enlarged about two and one-half diameters.

All photographed from specimens in the Carnegie Museum collected by Earl Douglass at Missoula, Montana. Figs. 1 and 3 from "Locality 196;" fig. 2 from "Locality 165."




*Betula* and *Quercus*.

(For explanation see opposite page.)

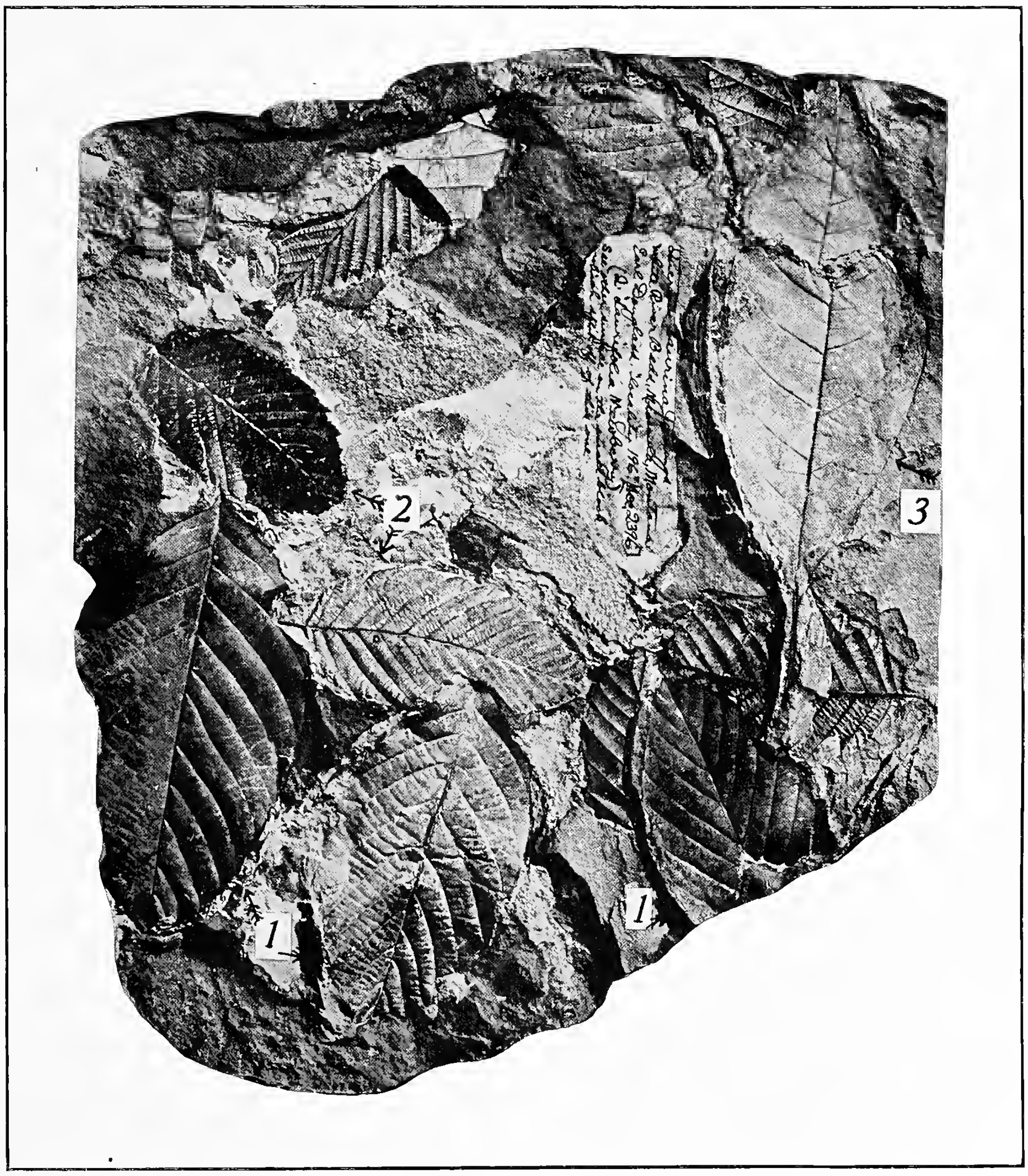
## EXPLANATION OF PLATE XXVIII.

FIG. 1. *Alnus Hollandiana* Jennings.

FIG. 2. *Betula multinervis* Jennings.

FIG. 3. *Quercus laurosimulans* Jennings.

About two-thirds diameter. Photographed from a specimen in the Carnegie Museum, collected by Earl Douglass at "Locality 196," Missoula, Montana.




*Alnus, Betula* and *Quercus*.

(For explanation see opposite page.)

## EXPLANATION OF PLATE XXIX.

Fig. 1. *Juglans pentagona* Jennings. Type. Natural size.

Fig. 1*a*. Part of same specimen, enlarged about two and one-half diameters.

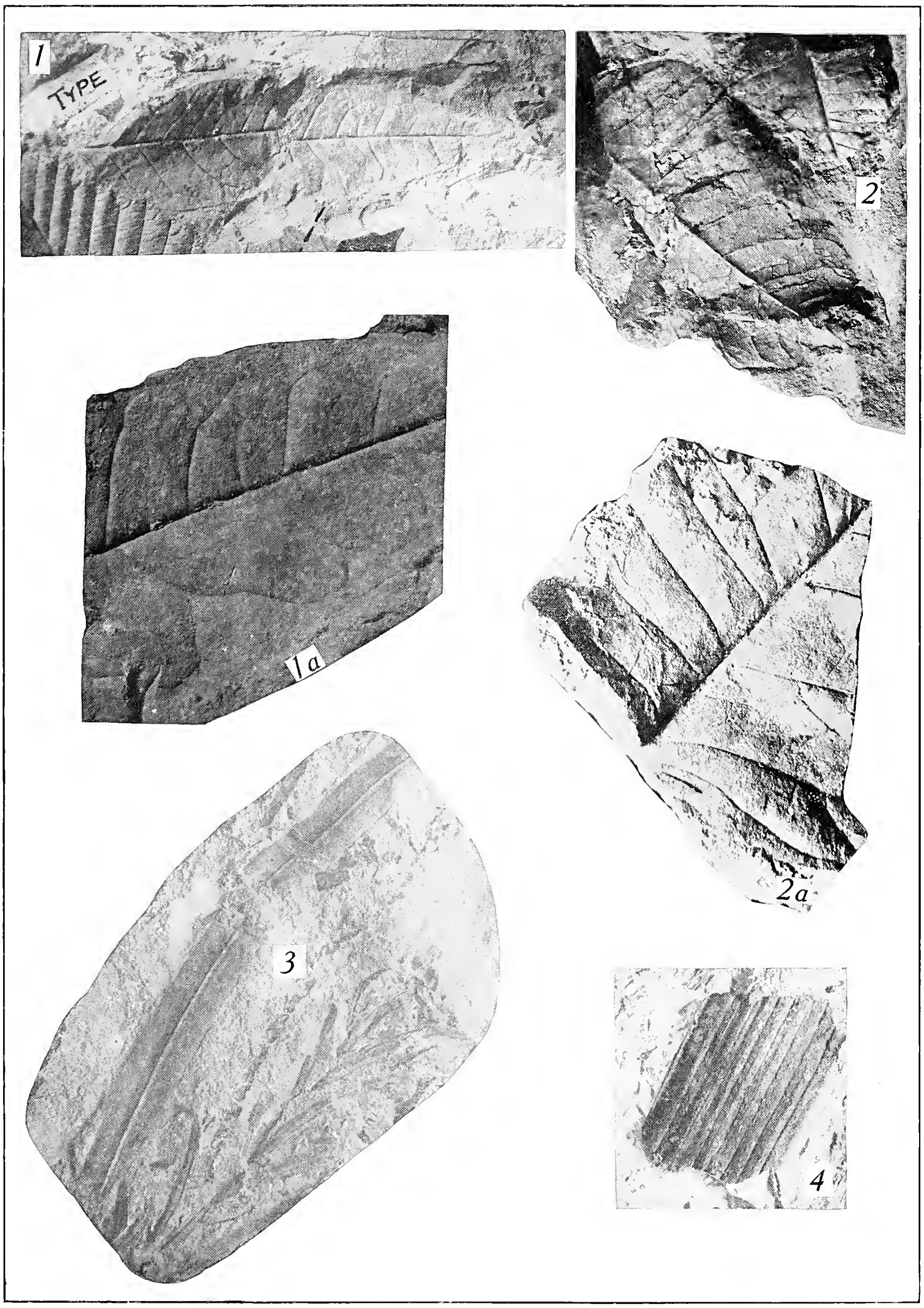
Fig. 2. *Juglans pentagona* Jennings. Natural size.

Fig. 2*a*. Part of the same specimen, enlarged about two and one-half diameters.

Fig. 3. *Cyperacites* sp. Enlarged two and one-half diameters.

Fig. 4. *Typha Lesquereuxi* Cockerell. Enlarged two and one-half diameters.

Photographed from specimens in the Carnegie Museum collected by Earl Douglass from Missoula, Montana. Figs. 1, 1*a*, 2 and 2*a* from "Locality 165;" figs. 3 and 4 from "Locality 196."




*Juglans*, *Cyperacites*, and *Typha*.

(For explanation see opposite page.)

## EXPLANATION OF PLATE XXX.

Fig. 1. *Alnus Hollandiana* Jennings. Type. Natural size.

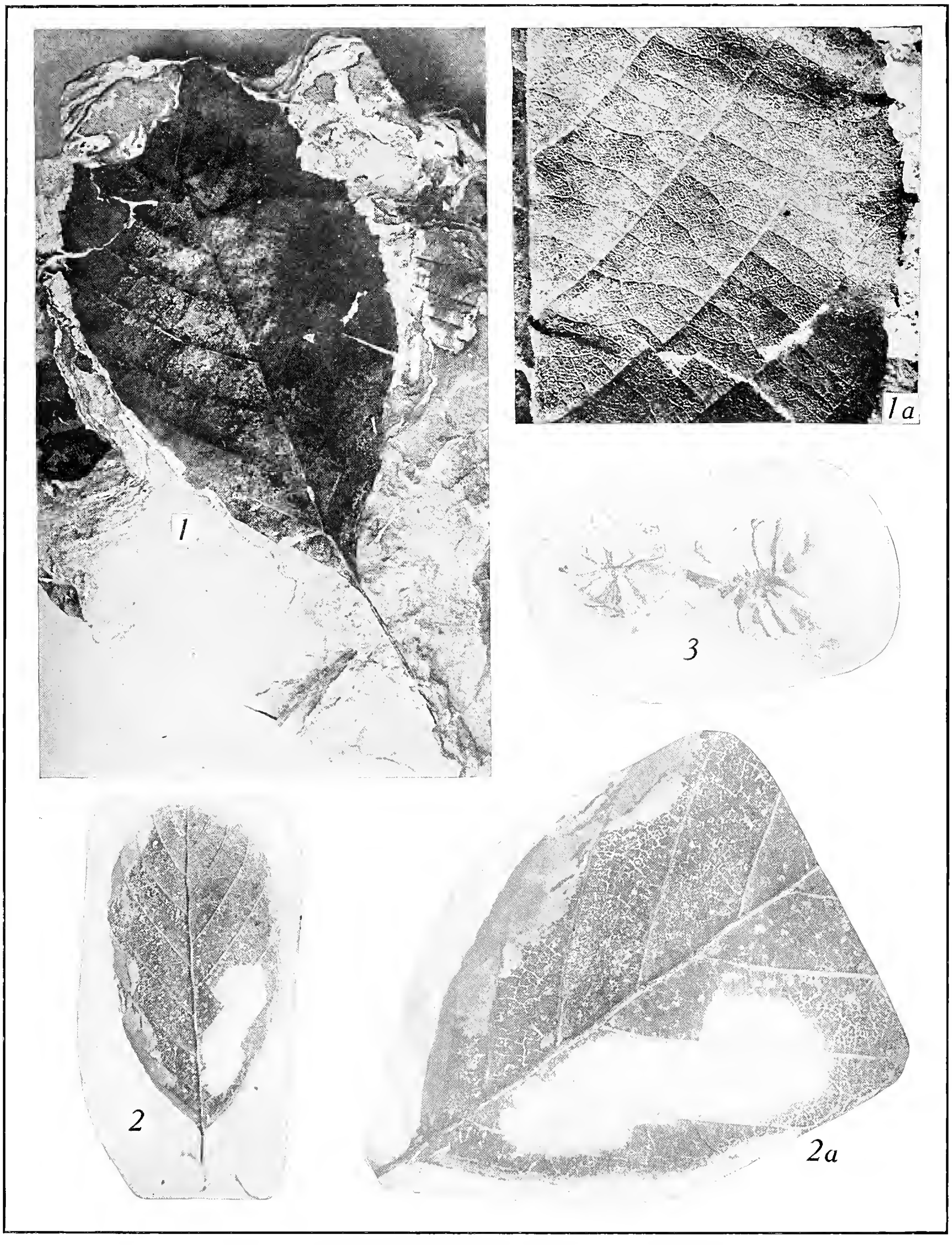
Fig. 1*a*. Middle right-hand margin of same, enlarged two and one-half diameters.

Fig. 2. *Alnus microdontoides* Jennings. Type. Natural size.

Fig. 2*a*. Lower part of same specimen, enlarged two and one-half diameters.

Fig. 3. *Alnus* cones. Enlarged about two and one-half diameters.

Photographed from specimens in the Carnegie Museum collected at "Locality 196," Missoula, Montana, by Earl Douglass.




*Alnus Hollandiana* and *A. microdontoides*.

(For explanation see opposite page.)

## EXPLANATION OF PLATE XXXI.

FIG. 1. *Quercus flexuosa* Newberry. Natural size.

FIG. 1*a*. Part of the same specimen, enlarged about two and one-half diameters.

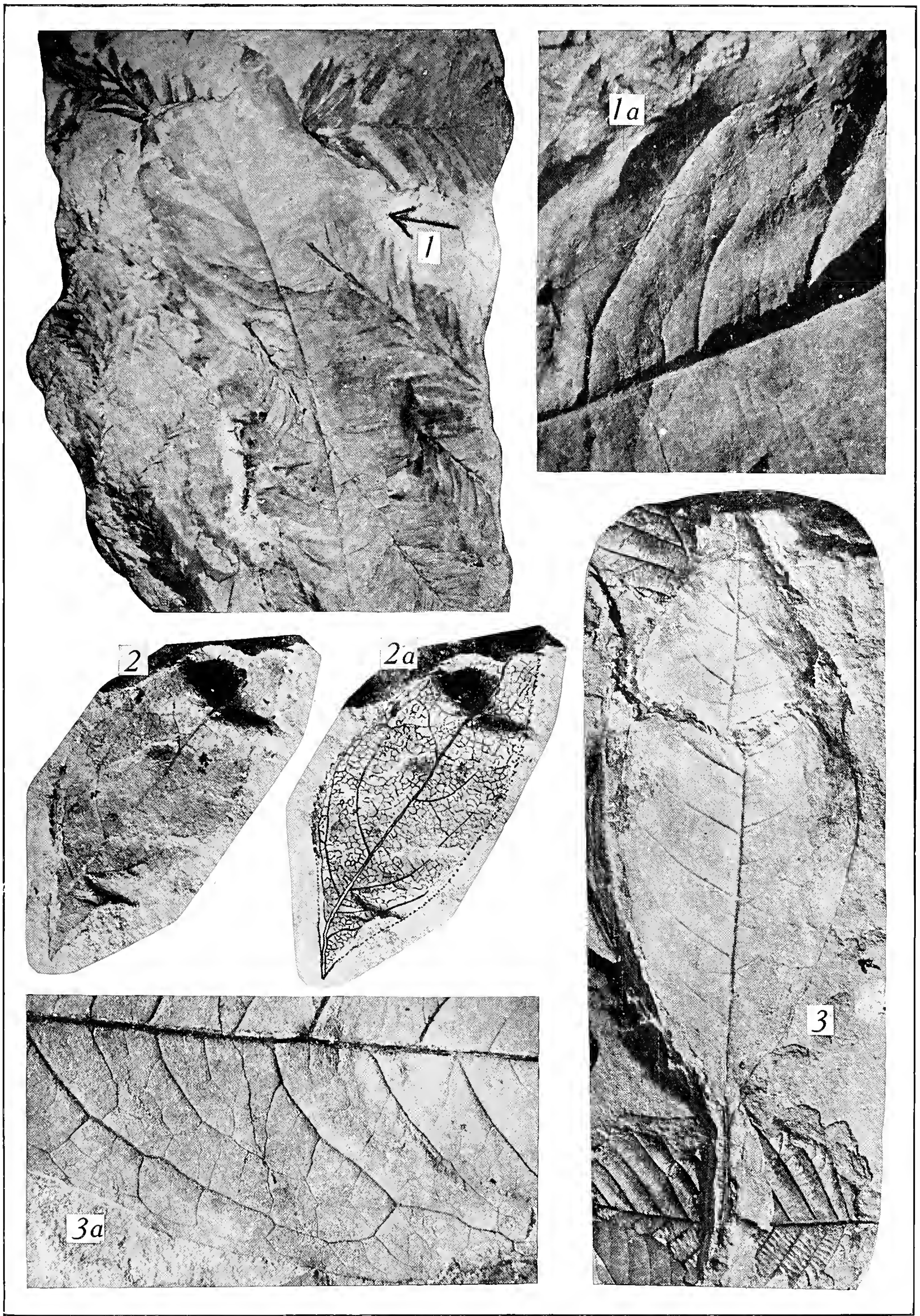
FIG. 2. *Celastrus parvifolius* Jennings. Type. Enlarged about two and one-half diameters.

FIG. 2*a*. Same with the venation inked in.

FIG. 3. *Quercus laurosimulans* Jennings. Natural size.

FIG. 3*a*. Part of another leaf from the same place, enlarged about two and one-half diameters.

All photographed from specimens in the Carnegie Museum collected by Earl Douglass at Missoula, Montana. Fig. 1 from "Locality 165"; figs. 2 and 3 from "Locality 196".




*Quercus* and *Celastrus*.

(For explanation see opposite page.)

## EXPLANATION OF PLATE XXXII.

Fig. 1. *Ficus* (?) *prunifolia* Jennings. Type. Natural size.

Fig. 1*a*. Part of same specimen, enlarged about two and one-half diameters.

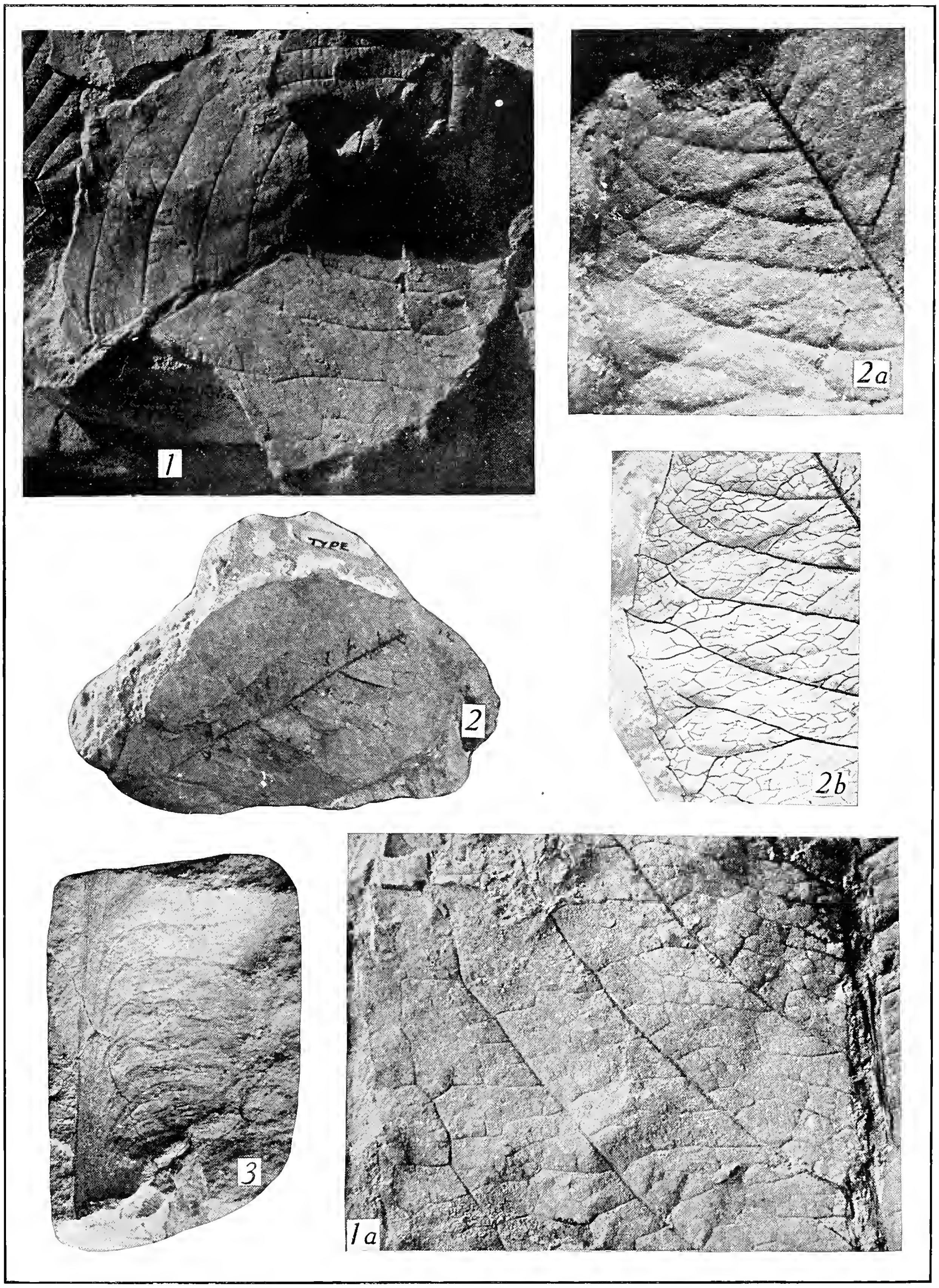
Fig. 2. *Ilex furcinervis* Jennings. Type. Natural size.

Fig. 2*a*. Upper part of same specimen, enlarged about two and one-half diameters.

Fig. 2*b*. Same as 2*a*, but with the margin inked in.

Fig. 3. *Acer oregonianum* Knowlton. Enlarged about two and one-half diameters.

Photographed from specimens in the Carnegie Museum collected at Missoula, Montana, by Earl Douglass; figs. 1 and 2 from "Locality 196", fig. 3 from "Locality 165".




*Ficus, Ilex,* and *Acer.*

(For explanation see opposite page.)

## EXPLANATION OF PLATE XXXIII.

Fig. 1. *Aralia longipetiolata* Jennings. Natural size.

Fig. 1*a*. Same, but with the venation inked in.

Fig. 2. *Aralia longipetiolata* Jennings. Base of a larger leaf, natural size. Type.

Fig. 2*a*. Same, with the venation inked in.

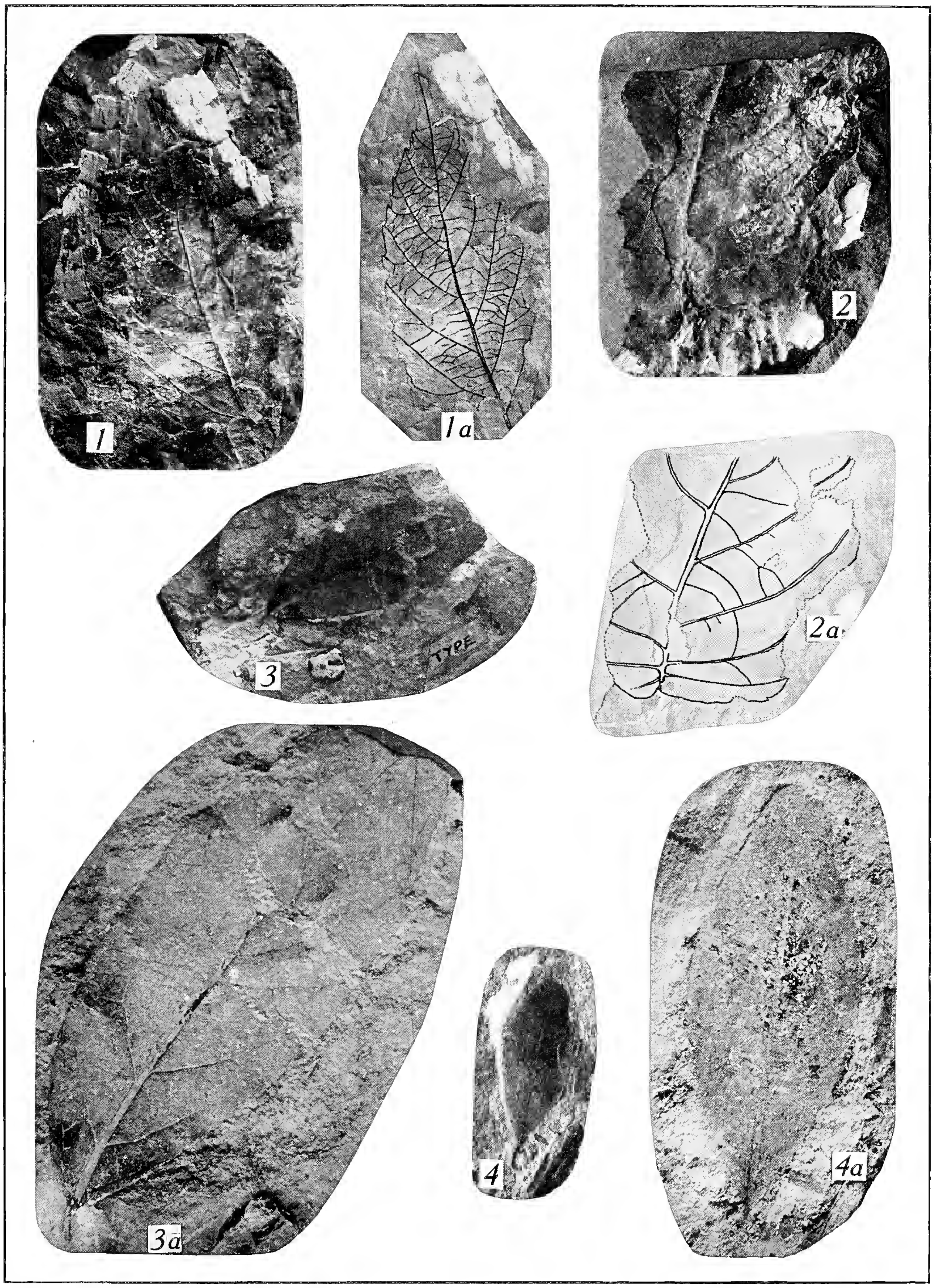
Fig. 3. *Vaccinium palæocorymbosum* Jennings. Type. Natural size.

Fig. 3*a*. Same, enlarged about two and one-half diameters.

Fig. 4. *Vaccinium palæocorymbosum* Jennings. Natural size.

Fig. 4*a*. Same, enlarged about two and one-half diameters.

All photographed from specimens in the Carnegie Museum, collected by Earl Douglass. Figs. 1 and 2 from "Locality 139", Winston, Montana; figs. 3 and 4 from "Locality 196", Missoula, Montana.




*Aralia* and *Vaccinium*.

(For explanation see opposite page.)

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OF THE

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VOL. VIII NO. 3

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# SOUTH AMERICAN NAIADES; A CONTRIBUTION TO THE KNOWLEDGE OF THE FRESHWATER MUSSELS OF SOUTH AMERICA

BY

DR. A. E. ORTMANN

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PITTSBURGH

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## SOUTH AMERICAN NAIADES; A CONTRIBUTION TO THE KNOWLEDGE OF THE FRESHWATER MUSSELS OF SOUTH AMERICA.


By Dr. A. E. Ortmann.


(Plates XXXIV–XLVIII)

### Introductory.

During the expedition of the Carnegie Museum to central South America, from 1907 to 1909, Mr. J. D. Haseman had as his prime object the collection of Fishes (Haseman, 1911)[1]. At the request of the present writer he, however, took particular pains to collect and preserve freshwater mussels. The result was one of the finest and largest collections of South American *Naiades* ever secured. The value of this collection is enhanced by the fact that a great number of specimens were preserved in alcohol with the soft parts, and the study of their anatomy has thus been made possible. Preliminary notes concerning the most important points of structure have been previously published (Ortmann, 1911a), chiefly in order to set forth the affinities of the South American forms with those of the rest of the world. Only a few typical forms were selected and discussed for this purpose. Further examination of the material has revealed a number of additional and highly interesting facts with regard to the anatomy, which throw light on the taxonomy and phylogeny of this group.

[1] The references in parentheses are to the papers found in the bibliography at the end of this paper.

The present paper is intended to give a full account of these investigations. Naturally all accessible material has been included. In many cases only shells without their soft parts were available. This remark refers largely to older and some more recent material preserved in the Carnegie Museum obtained from various sources. The Haseman Collection likewise contains only the hard parts of many species, but on the other hand, other accessions consisted of shells with soft parts, as, for instance, the specimens of *Anodontites crispatus* from the upper Magdalena-drainage in Colombia, collected by Dr. C. H. Eigenmann, and a collection of a number of species from the La Plata in Argentina, received from Dr. A. Windhausen.

In spite of the comparative wealth of material at hand, in some respects our collections are not complete and do not permit the determination of certain questions, chiefly taxonomic. My greatest difficulty has been to properly identify the "species" at hand. The older writers, Spix, Wagner, Lea, D'Orbigny, Philippi, Hupé, and others, generally described their "species" from very insufficient material, and the author to whom we are most indebted for clearing up the taxonomy of the South American *Naiades*, H. Von Ihering, also was often handicapped by having too scanty material. All previous writers had no clear conception of the range of variation in the various forms, and thus their descriptions generally are those of individuals, often indeed very elaborate and complete, but without proper emphasis laid upon the really important specific characters. Simpson's "Descriptive Catalogue" (1914) did not much improve matters, since he was largely dependent upon the unsatisfactory publications of previous authors.

I do not claim, by any means, that my treatment of these shells overcomes all these difficulties; on the contrary, I am in many particulars not at all satisfied with the results obtained. Nevertheless, I claim that the study of the soft parts of a great many forms has furnished a basis for the proper understanding of what the "species" are, and has, at least, furnished a clue to their systematic arrangement, incomplete and fragmentary, it may be, but which probably will prove to be of great value, when the soft parts of all or most of the species are known.

The difficulty encountered in recognizing the described forms is sometimes exasperating. We should expect, in cases where exact type-localities are given, and where material from these is at hand, that it would not be very great. But, for instance, even of the species described by Von Ihering from São Paulo, I have recognized only a comparatively small number, although I possess a large quantity of material representing the *Naiades* from that state. In other cases, when the type-locality is vaguely, or not at all, given, it has been practically impossible to

be sure of the identification. In consequence I have been compelled to introduce a number of "new species," although I am afraid that some of them are not really "new." But I must leave the task of making out their synonymy to others, who have access to authentic material representing the older forms. It should also be remembered that the introduction of new names is justified by the rules of nomenclature, when an original description is insufficient to enable the species to be recognized.

## General Remarks as to the Affinities and Geographical Distribution of the South American Naiades.

The earlier writers generally placed the South American forms in the old collective genera, *Unio* and *Anodonta*, to which a kind of intergrading group, called *Monocondylæa*, and certain specialized types, such as *Hyria* and *Castalia*, were added. Von Ihering was the first to recognize that the South American "*Anodonta*," so-called, differs from the *Anodonta* of the northern hemisphere in important characters, and that it is related to certain African forms, *Mutela*, *Spatha*, etc. He calls this genus *Glabaris* Gray = *Anodontites* Bruguière. But he left the other forms under *Unio*. For these Simpson (1900) used the name *Diplodon* Spix. In my preliminary report on South American *Naiades* (Ortmann, 1911a, pp. 108, 120, 129, 130) I was able to show that *Diplodon*, as well as *Hyria* and *Castalia*, differ anatomically from the *Unionidæ* of the northern hemisphere, and that Von Ihering's separation of *Glabaris* from *Anodonta* is fully justified and correct. I also found that the genera *Hyria*, *Castalia* (= *Tetraplodon*), and *Diplodon*, recognized by Simpson as a peculiar group, but still placed with the *Unionidæ*, are actually more nearly allied to "*Glabaris*," and form with this a group, the family *Mutelidæ*, which should be divided into two subfamilies, the *Hyriinæ* and *Mutelinæ*, each with a number of genera, the anatomy of many of which, however, was still unknown.

Subsequent investigations brought out the fact that Simpson (1900) was correct in associating certain Australian *Naiades* with the South American *Diplodon*, since I was able to show that *D. australis* has practically the same anatomical structure as the South American *Diplodon* (Ortmann, 1912), but that it should be elevated to the rank of a separate genus, *Hyridella* Swainson, admitted as a subgenus by Simpson.

The systematic arrangement and geographical distribution of the families and subfamilies of the *Naiades* would thus be as follows:

Superfamily NAIADES.

I. Family MARGARITANIDÆ.........Eurasia and North America (discontinuous).

II. Family UNIONIDÆ:

1. Subfamily UNIONINÆ.......Eurasia, Africa, North America, southward to Central America.

2. Subfamily ANODONTINÆ.....Eurasia, North America, southward to Central America.

3. Subfamily LAMPSILINÆ .....North America southward to Mexico.

III. Family MUTELIDÆ:

1. Subfamily HYRIINÆ........South America (but not in Central America), Australia.

2. Subfamily MUTELINÆ ......South America to southern Mexico, Africa.

I can not improve upon this arrangement at present. It possibly might be advisable, in future, to elevate the two South American subfamilies to the rank of families, but I refrain from doing this, chiefly because the African and Australian forms belonging to them are too poorly known. The fact that in South America two groups of *Naiades* are found, which are more closely allied to each other than to any other group, is well expressed by uniting them into *one* family (*Mutelidæ*).

The more primitive subfamily, *Hyriinæ,* is found all over South America, but becomes rare in the northern parts (Venezuela and Colombia), and is missing, so far as known, in Central America. It is quite abundant in Chile, where the *Mutelinæ* are absent, and it is also found in Australia.[2]

The more specialized group, subfamily *Mutelinæ,* is found in South America, east of the Andes. It is missing in Chile, but has been reported from the Pacific drainage in Ecuador. It goes into Central America and reaches southern Mexico. On the other hand it is represented in Africa, probably all over the continent, with the exception of the Mediterranean region.

This geographical distribution of the larger groups is extremely significant, for it serves to support certain theories as to the origin of the South American continent, its former connections, and the origin of its fauna. The presence of the *Hyriinæ* both in South America and Australia indicates the former connection of both continents, probably by way of Antarctica, and the fact that species of *Diplodon*, the most primitive of the South American *Hyriinæ*, are found in Chile, is entirely in keeping with this. The fact that *Unionidæ* with certain Hyriine structures[3] are found chiefly in southeastern Asia, suggests that they probably

[2] It is unknown whether all the Australian *Naiades* belong here. *Unionidæ* related to the *Hyriinæ* in having the septa of the marsupium interrupted, are known to me from southeastern Asia (Siam, China) and northwestern America (Pacific slope), but these forms certainly are *Unionidæ* in all other respects.

[3] Interrupted septa in the marsupium are known in the Asiatic *Unioninæ: Lamellidens* (Ortmann, 1911*a*, p. 106); in *Hyriopsis* and *Contradens* (Ortmann, Nautilus, XXX, 1916, pp. 85 and 106); and, according to the figures of Haas (System. Conchyl. Cabin., XIX, 1911 and 1912), also in *Rectidens* and *Acuticosta*.

originated on the old connecting land between Asia and Australia (Sino-Australian continent) or in Australia, and that *Diplodon* first reached Chile (in Mesozoic times) coming from Australia, and subsequently invaded the Brazilian mass. The modern forms of the *Hyriinæ* (*Castalia, Hyria*) chiefly have their center in the basin of the Amazon, a comparatively young part of the continent.

The more advanced type, represented by the subfamily *Mutelinæ*, developed probably in Brazil at the end of the Mesozoic, when it had a chance to spread over the old connection across the Atlantic (Archhelenis of Von Ihering), and the immigration of this stock into Central America is of rather late date (late Tertiary). It is not very likely that the *Mutelinæ* reached South America coming from Africa, because there is no trace of them found in southern Asia.[4]

## Diagnostic Characters of the South American Naiades.

(See Text-figures 1, 2, 3.)

### Family: MUTELIDÆ Ortmann (1911).[5]

1. Diaphragm between branchial and cloacal cavity formed anteriorly by the gills, posteriorly by a solid union of the mantle margins (Figs. 1, 2, 3, t). (No such mantle connection in *Unionidæ*).

2. Anterior end of inner gill (Figs. 1, 2, 3, i) broadly attached, and in contact with posterior base of palpi (h). (In the *Unionidæ*, there is always a longer or shorter space between these parts.)

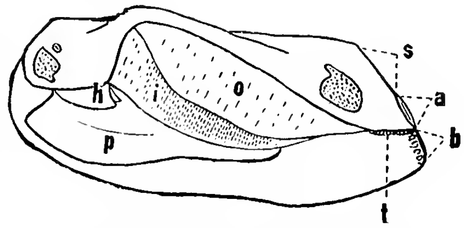


Fig. 1. Diagram of soft parts of female of *Diplodon trifidus* (Lea). Natural size, left section of mantle removed. *a*, Anal opening; *b*, Branchial opening; *h*, Palpi; *i*, Inner gill; *o*, Outer gill; *p*, Pes; *s*, Closed part of anal opening; *t*, Union of mantle separating anal and branchial openings.

3. Anal and branchial openings (a and b) sharply separated from each other by the union of the mantle margins (See Character 1); anal opening open or closed above, but there never is a supra-anal opening. (In the *Unionidæ*, the anal may be open, but, when closed, there is always a supra-anal opening.)

[4] In Africa there are also *Unionidæ* of the subfamily *Unioninæ;* they undoubtedly point to a connection with Asia, since such forms are plentiful there, and this indicates a different route of immigration from that of the *Mutelinæ*.

[5] The name depends upon the investigation of the anatomy of the African genus *Mutela*, which is unknown, but we have every reason to assume, chiefly through Von Ihering's study of the shell, that this genus will fall under this family. The family name *Mutelidæ* was first used by H. & A. Adams (1858), but for an entirely different association of forms. The *Mutelidæ* of Simpson (1900) correspond to our *Mutelinæ*.

4. Gills with or without water-tubes, and with isolated, scattered interlaminar connections, or with interrupted or solid septa. (In the *Unionidæ*, mostly uninterrupted septa and water-tubes are found; very rarely are they interrupted; the forms with the latter probably form the connection with the *Mutelidæ*.)

5. Marsupium only in the inner gill (Figs. 1, 2, 3, i). (In the *Unionidæ*, the marsupium is either in all four gills, or in the outer gills, never in the inner gills alone.)

6. Certain advanced genera of the *Mutelidæ* show a tendency to close the branchial opening in front by a mantle connection. (Such a connection is entirely unknown in the *Unionidæ*.)

The foregoing are the anatomical characters. The shape of the shell and its parts are subject to so many variations, both in the *Mutelidæ* and the *Unionidæ*, that it is practically impossible to point out general differentiating characters. Different and often very peculiar types of shell, occurring independently, are frequently observed, so that it is clear that the shells by responding to certain stimuli and requirements have acquired similar shapes in forms, which belong to different families (convergency or parallelism). Simpson (1900 and 1914) found it impossible to give shell-characters for his subfamily "*Hyrianæ*" = *Hyriinæ*+certain *Unioninæ*, except beak-sculpture, and he was mistaken in this. In our arrangement, this is the only character, which might be mentioned, but not without qualification. We may express it thus: The *Mutelidæ* have radial beak-sculpture, if such is present at all);[6] while the *Unionidæ* rarely have distinct radial beak-sculpture, but commonly other types, zig-zag, double-looped, or concentric.

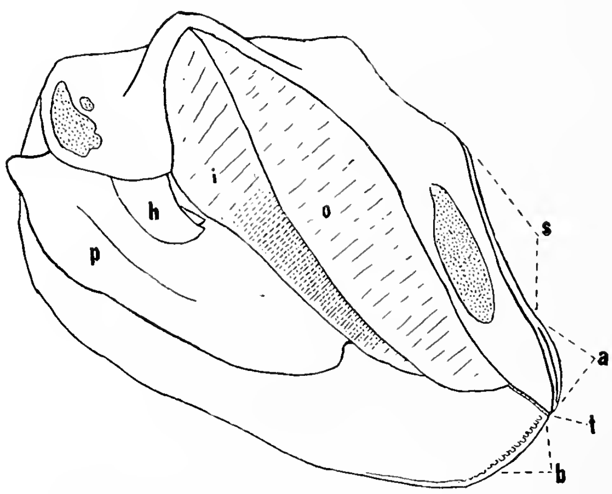


FIG. 2. Diagram of the soft parts of female of *Castalina nehringi* Von Ihering. Natural Size, left section of mantle removed. (Lettering as in Text-figure 1, p. 455.)

Some *Mutelidæ* have, indeed, shells which completely mimic those of certain *Unionidæ*. Species of *Diplodon* often externally so much resemble certain species

[6] But even this should be qualified. In certain species of *Anodontites* in the subfamily *Mutelinæ*, I have observed something like concentric beak-sculpture, while, as a rule, the *Mutelinæ* have no beak-sculpture whatever.

of the North American *Elliptio,* that without a minute examination of muscular impressions, hinge-teeth, etc., it is impossible to recognize them, when the locality is unknown. The only reliable character in this case, beak-sculpture, is often obliterated by erosion. Species of *Anodontites* often look like species of *Anodonta.* Here the examination of beak-sculpture, muscular impressions, and the ligamentinal sinus establishes their affinity. On the other hand, there are *Mutelidæ* which are easily recognized by the peculiar shape of the shell, and could never be confounded with *Unionidæ* (*Castalia, Hyria, Mycetopoda,* etc.).

The characters of the two subfamilies of the *Mutelidæ* are the following:

### Subfamily Hyriinæ Ortmann (1911).

*Hyrianæ* Swainson (1840), very closely corresponds to this. *Lamphoramphus*-group of *Hyrianæ* Simpson (1900).

1. Anal opening (Figs. 1, 2, *a*) closed above (*s*), slit-like (in South American forms), or forming a short, tubular siphon (Australian forms).

2. Marsupium generally an interrupted network of interlaminar connections (Figs. 1, 2, i), the connections often standing in rows, thus forming incomplete septa and incomplete, communicating, water-tubes. In rare cases, the interlaminar connections of the marsupium (but not of the non-marsupial gills) form solid septa and isolated water-tubes. Marsupial part of gill often restricted to only a section of it.

3. Non-marsupial gills always with poorly developed, scattered interlaminar connections. (Figs. 1, 2, *o*.)

4. Inner lamina of inner gills always entirely connected with abdominal sac.

5. Palpi (Figs. 1, 2, *h*) subtriangular or subfalciform, with gently curved lower margins, and somewhat produced posterior points.

6. Larva a glochidium (See Fig. 4, p. 469).

As a character of the shell may be mentioned the beak-sculpture, which is generally present (often poorly developed, rarely absent), and always radial. The hinge-teeth are always present, and generally well-developed. Dorsal muscle-scars are present.

### Subfamily Mutelinæ Ortmann (1911).

*Mutelidæ* Adams (1858), Simpson (1900). The name depends, of course, on the genus *Mutela,* the anatomy of the soft parts of which, as has been pointed out already, remains to be investigated.

1. Anal opening (Fig. 3, *a*) open (in South American forms, except *Mycetopoda*) or closed above (in African forms and *Mycetopoda*), slit-like.

2. Marsupium (Fig. 3, *i*) with well-developed, continuous septa, forming well-defined, isolated water-tubes, with a peculiar longitudinal ridge or swelling on the septa near the outer lamina of the gill (Pl. XLVIII, figs. 6, 8). When gravid, only the inner compartment of the water-tubes (towards the inner lamina) is somewhat extended and filled with eggs; the outer compartment becomes a secondary water-tube (Pl. XLVIII, fig. 7*b*).

3. Non-marsupial gills (Fig. 3, *o*) also with septa and water-tubes, but the septa less strongly developed and without a ridge.

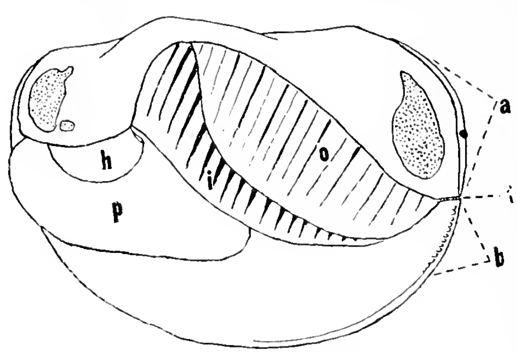


Fig. 3. Diagram of soft parts of female of *Anodontites patagonica rubicunda* (Lea). Natural size, left section of mantle removed. *a*, Anal opening; *b*, Branchial opening; *h*, Palpi; *i*, Inner gill; *o*, Outer gill; *p*, Pes; *t*, Union of mantle separating anal and branchial openings.

4. Inner lamina of inner gills entirely connected with abdominal sac (South American forms), or free from it (African forms).

5. Palpi nearly semicircular, longer than high, with a short posterior truncation, strongly curved lower margins, and indistinct posterior points (Fig. 3, *h*).

6. Larva supposed to be a lasidium (according to Von Ihering).

The shell generally has no beak-sculpture whatever. In very rare cases a trace of concentric sculpture has been observed (see under *Anodontites trapezea*). Hinge-teeth more or less obsolete, reduced in number, or size, and very often entirely absent (Anodontine type of hinge). Dorsal muscle-scars mostly absent in South American forms, very rarely a faint trace seen, or a few are present, as in *Leila*. In African forms, there is one single well-developed dorsal muscle-scar.

## Subfamily HYRIINÆ Ortmann.

### General Remarks.

Shell of various shapes, subelliptical, subtrapezoidal, subovate, suborbicular, or subtriangular, sometimes more or less alate. Beak-sculpture mostly present, rarely missing, but often indistinct or obliterated by erosion, always of the radial type, with two sets of radial ridges, starting from two points, immediately in front and immediately behind the tip of the umbo, and extending to a varying degree upon the disk. The posterior ridges of the anterior set, and the anterior ridges of the posterior set, generally interfere with each other in the middle of the disk,

coming there into contact in a sharp angle. There are sometimes irregularities in the beak-sculpture obscuring their radial character.

Hinge-teeth always present, but rather variable in number, size, and shape. Normally, there are, as in most other *Naiades,* two laterals in the left valve, and one lateral in the right valve, but individual variations may occur in this respect. The pseudo-cardinals are much more variable. Originally their arrangement seems to be similar to that found in primitive *Unionidæ*: that is to say, there are two in the left valve, and one or three in the right; of the latter, the middle one may be the main tooth, fitting in between the two teeth of the left valve, and the anterior and posterior tooth may be accessory. However, this arrangement is very often changed by the suppression of certain teeth, and the addition of others. The most general condition is when of the two pseudocardinals of the left valve the posterior is more or less obsolete, and often entirely wanting, and only the two anterior teeth of the right valve are present. Thus the left valve appears to have only one pseudocardinal (*Aspidon* of Von Ihering) and two laterals, and the right valve has two pseudocardinals (*Dexion* and *Epidexion*), and one lateral. This is chiefly the case in certain species of *Diplodon,* where the pseudocardinals are greatly compressed, and directed more or less parallel to the hinge-line, and this should be kept in mind for the distinction of those species of *Diplodon,* which resemble in shape certain North American species of *Elliptio,* where the normal arrangement shows two pseudocardinals in the left, and one in the right valve.

This is not the only variation. Additional teeth may turn up, and chiefly when in the left valve anterior to (or above) the anterior pseudocardinal an additional tooth is developed (*Epaspidon,* Von Ihering).

The names *Aspidon* and *Epaspidon, Dexion* and *Epidexion,* may be used to advantage; but we should not forget that originally there is in the left valve a tooth behind the *Aspidon* (regarded by Von Ihering as being accessory), and that there is often in the right valve another (third) posterior tooth, behind the *Dexion.*[7]

Further, there is much variability in the shape of the teeth. The pseudo-cardinals, as has been stated, are often compressed, lamellar, and smooth. But often they are more solid, or stumpy, when they are frequently more or less split and divided, sometimes almost cut up into a number of teeth. The laterals may be smooth or corrugated, the corrugations standing obliquely on the faces; and in certain genera there are characteristic regular and parallel striations or ridges

[7] Compare also Odhner, 1918, p. 574 ff. (Homologies of hinge-teeth of "*Unionidæ*"). Odhner seems to be right in a general way, but the hinge of the *Naiades* is extremely complex and individually variable.

standing vertically to the edge of the teeth. Similar ridges may be present on the pseudocardinals.

In the shape of the muscle-scars on the inside of the shell, there exists no great difference between the *Hyriinæ* and *Mutelinæ*. The general rule is in the *Hyriinæ* that the upper anterior retractor-scar is distinctly separated from the anterior adductor impression, while the lower anterior retractor-scar is confluent with the latter. Very rarely the lower anterior retractor-scar is isolated. (In the *Mutelinæ* either all three scars are confluent, or the lower anterior retractor-scar is isolated; the upper anterior retractor-scar is hardly ever isolated). The posterior muscle-scars are confluent, the posterior retractor-scar forming a small process at the upper margin of the adductor-scar. The muscle-scars may be deeper or shallower, the upper anterior retractor-scar generally is rounded, small, and remarkably deep.

Dorsal muscle-scars are present in the *Hyriinæ* (mostly absent in the *Mutelinæ*); they are variable in number, generally only a few, and are located in the bottom of the shallow beak-cavity, forming an irregular row parallel to the hinge-line, or somewhat oblique. In some forms with deep beak-cavities, these scars are situated on the inner side of the hinge-plate (behind the pseudocardinals and the interdentum).

The line of the mantle-impression is always simple, without a sinus posteriorly. The ligamental sinus lies on the margin of the shell behind the ligament, over the posterior part of the lateral teeth (rarely more in front), and is always small and shallow (longer than deep). (In the *Mutelinæ*, the ligamental sinus is generally much deeper, with a sharp lower point.)

The characters of the soft parts of the *Hyriinæ* have been pointed out above.

## The Genera of the Hyriinæ.

The genera of the *Hyriinæ* have been hitherto differentiated according to the shape of the shell, the character of the beak-sculpture, and the character and the sculpture of the hinge-teeth. According to Simpson (1914 pp. 1194 ff.) there are seven of them in South America: *Tetraplodon* Spix (*recte Castalia* Lamarck); *Castalina* Von Ihering; *Castaliella* Simpson; *Callonaia* Simpson; *Hyria* Lamarck; *Prisodon* Schumacher; *Diplodon* Spix.

In addition, there are species belonging to this group in Australia (and probably also in New Zealand), which have been placed by Simpson in *Diplodon*, but have been separated by him under the subgenus *Hyridella* Swainson. I have shown (Ortmann, 1912) that the type of *Hyridella* (*Unio australis* Lamarck) actually is closely allied to *Diplodon*, but that probably it is better to regard *Hyridella* as a genus by itself.

The differences of the South American genera may be tabulated as follows:

*a.* Shell not alate, or only very slightlyalate behind, subelliptical, subovate, subrotund, or subtriangular.

*b.* Shell subelliptical, subovate, or subrotund, but not subtriangular. Beaks not much elevated, with radial beak-sculpture, variously developed. Posterior ridge absent or poorly developed; when present and distinct, the shell is elongated. Hinge teeth more or less smooth or dissected, or corrugated, but without vertical parallel ridges. Interdentum very narrow. *Diplodon.*

*bb.* Shell subtriangular (or subquadrate). Beaks more or less elevated and with rather deep beak-cavities. With or without beak-sculpture. Posterior ridge well developed, defining a distinct posterior slope. Hinge-teeth generally much dissected, and often with parallel vertical ridges. Interdentum well developed, rather broad.

*c.* Sides of shell somewhat flattened, posterior ridge moderate, posterior slope elevated in the middle and slightly alate (thus the shell becomes subalate). Hinge-teeth smooth, crenulated, or with parallel ridges. . . . . . . . . . *Castalina.*

*cc.* Sides of shell more or less convex, posterior ridge sharp, posterior slope truncated, not elevated (or only so in the young). Hinge-teeth with parallel ridges.

*d.* Radial beak-sculpture present.

*e.* Beak-sculpture strongly developed, extending over a large part of the disk. Surface not concentrically sulcated. . . . . . . . . . *Castalia.*

*ee.* Beak-sculpture short anteriorly, extending farther on the disk posteriorly. Surface covered with strong, even, concentric ridges (sulcated). . . . . . . . . . *Castaliella.*

*dd.* Beaks without distinct sculpture, and surface of shell smooth. . . . . . . . . . *Callonaia.*

*aa.* Shell subrhomboidal or subtriangular, strongly alate behind, slightly alate in front.

*b.* Beaks with strong radial sculpture. Posterior ridge moderately developed. . . . . . . . . . *Hyria.*

*bb.* Beaks without sculpture. Posterior ridge strongly developed, sharp and high. . . . . . . . *Prisodon.*

From the expressions used in distinguishing these genera, it appears that *Diplodon* is a rather composite genus, containing shells of various, more or less indifferent types, while the other genera represent more marked and peculiar shapes, with *Castalina* forming, to a degree, a connection between *Diplodon* and the rest. This indicates that *Diplodon* includes the more primitive and generalized forms of the subfamily, while the others are more specialized and advanced. In a general way, this is supported by the investigation of the anatomy. However, it is much to be regretted that I am unable to give any information as to the structure of the soft parts of the genera *Castaliella* and *Callonaia*. The former is entirely unknown to me, and of the latter I possess only two odd valves. Also of *Prisodon* I only have the soft parts of a young individual. Better material is at hand to represent the other genera.

Generally speaking, the anatomy of all these forms is rather uniform; yet there are certain characters in which they differ, and some of these, indeed, indicate a gradual advance in the structure.

One of these characters has been noticed long ago, and has been discussed in detail by Von Ihering. This is the tendency manifested in certain forms to close the branchial opening in front by a connection of the mantle-margins, which is a character entirely wanting in the *Unionidæ*, but it is found occasionally in both subfamilies of the *Mutelidæ* (*Hyriinæ* and *Mutelinæ*). But numerous members of this family do not have this character, and thus it is evident that the absence of this mantle-connection indicates a primitive condition, while its presence is a more advanced stage, expressing the tendency to transform the branchial opening into a closed tube (siphon).

According to Von Ihering (1898), the mantle-connection closing the branchial opening anteriorly is always present in *Castalia*. I have been able to confirm this only partially. Of typical species of *Castalia* I possess the soft parts of six specimens of *C. acuticosta:* they show the branchial opening closed with one exception, where it is open. In *C. undosa*, a somewhat aberrant type, Von Ihering describes the branchial as normally closed, but he says that in four out of twenty-one specimens examined the mantle-connection was missing.[8] Of this species I have five specimens with soft parts, of which three have the branchial closed, while it is open in two of them. In one of the latter, however, a small one, it may be torn. It must be admitted that also in other cases this connection of the mantle may have been torn in life or in preservation.[9] And thus it might be that *normally* this mantle-connection is present in *Castalia*.

*Castalina*, according to Von Ihering, varies in the development of this character in the different species and individuals. He has investigated two males of *C. nehringi*, and one had the branchial closed, the other open. In eight females examined by myself, I found the branchial open. In *C. martensi* Von Ihering found the branchial opening in most cases closed. I have no soft parts of this species. But in two specimens of *C. psammoica*, which I possess, one has this opening distinctly closed in front, in the other this is not the case.

Nowhere else within this subfamily has this character been found. *Castaliella* and *Callonaia* may possess it, but their anatomy is unknown. Of *Hyria* and *Prisodon*

[8] In Von Ihering's description (1893, p. 86) there is a very singular mistake. He speaks of the mantle-connection "Bruecke" between the two "siphons," while he undoubtedly means the connection in front of the branchial "siphon." This is the one which is sometimes missing. The absence of the connection between the anal and branchial openings would be something unheard of; in fact, has never been observed by me in any member of the family.

[9] We must recall that similar variations or mutilations with regard to the mantle-connection which separates anal and supra-anal openings in the *Unionidæ* are well established, for instance in the genus *Fusconaia*.

it is positively known that no such mantle-connection exists, and the same is the case in all investigated species of *Diplodon.*

Thus it is seen that *Castalina* and *Castalia* (and possibly also *Castaliella* and *Callonaia*) form a group within the subfamily, which is not only specialized in the shape of the shell, but also in the tendency to close the branchial opening anteriorly. As *Castalina* forms a transition from *Diplodon* to *Castalia* in the shell, so it is transitional also in this latter character, and thus it is perfectly clear that *Castalina* and *Castalia* cannot be primitive types, and other peculiar characters, which they possess, probably also should not be regarded as primitive.

This is especially true of the parallel ridges vertical to the edge of the lateral hinge-teeth (also sometimes present on the pseudocardinals). This character is best developed in *Castalia* (Plate XXXIX, figs. 8*c*, 8*d*), but *Castaliella* is also described as showing traces of it, and *Callonaia* has it. But here again *Castalina* is transitional toward *Diplodon. Castalina nehringi* has, according to Von Ihering, hinge-teeth obliquely corrugated, but never with parallel ridges vertical to the edge. This is quite correct, as far as concerns the laterals; but some of my specimens show that the furrows of the cardinal teeth occasionally may be nearly parallel, thus producing nearly parallel ridges. In *Castalina martensi* vertical ridges are present and well-developed, at least in the anterior section of the lateral teeth, but young specimens do not show them. My specimens of *Castalina psammoica* have the vertical ridges poorly, or not at all, developed.

This sculpture of vertical ridges upon the hinge-teeth in *Castalia* and the allied genera has been much discussed in the literature. It is well known that Neumayr believed that these ridges are homologous to similar structures seen in the *Trigoniidae,* and that *Castalia* should be directly connected with *Trigonia,* and this idea has been taken up by other authors. However, Von Ihering (1893 p. 85) has pointed out that this is incorrect. From the above considerations we now know, that there undoubtedly is a genetic series, which leads from *Diplodon* through *Castalina* to *Castalia,* with the *beginning* at *Diplodon,* and the *end* at *Castalia;* and, consequently, the vertical ridges on the hinge-teeth in *Castalia* are not an ancestral character, inherited from *Trigonia,* but are a new acquisition, marking an independent, comparatively high development of the Naiad-hinge.[10]

*Hyria* and *Prisodon* may, or may not, possess these vertical ridges on the hinge-teeth. If present (*Prisodon alatus,* Pl. XL, figs. 2*c*, 2*d*), they are seen chiefly in

[10] This idea has also been suggested by Pompeckj (Gegen Steinmann's Geologische Grundlagen der Abstammungslehre, im 3ten Jahr.-Ber. Niedersæchs. Geol. Ver., 1910, p. 12) in criticizing Steinmann's attempt at a polyphyletic derivation of the *Naiades* from various *Trigoniidæ.* Odhner (1918, p. 577, footnote) also considers the sculpture of the teeth in *Castalia* as a secondarily developed character.

old specimens, while they are lacking in the younger ones, but old specimens also may not show them. Thus these two genera should be compared in this respect with *Castalina*, and it is quite possible that they have here their roots, the shape of the shell of *Castalina* also indicating in its elevated posterior slope the "alate" shape of *Hyria*.

Thus we see that the genera *Castalina, Castalia*, and probably also *Castaliella* and *Callonaia*, form a series descended from *Diplodon*, characterized by peculiar tendencies in the shell and in the soft parts. The shell tends to assume a more or less triangular shape, with high beaks, with a strong posterior ridge, and a truncated posterior slope. The hinge-teeth tend to develop vertical ridges, and the interdentum becomes wider. The soft parts tend to close the branchial opening in front. All the rest of the soft parts, however, remain here in a comparatively primitive state, being identical with, or standing very close to, the most primitive type of *Diplodon* in the interrupted character of the septa of the gills (See below). It also should be mentioned that the glochidia of these forms, where known, as in *Castalina* and *Castalia*, possess the same shape and the peculiar hooks observed in many species of *Diplodon*, but not in all (See below).

Apparently a side-branch of this series is formed by *Hyria* and *Prisodon*. Here the "alate" character of the shell, slightly indicated in *Castalina*, is emphasized, and developed to an extreme degree; the hinge-teeth have a slight tendency to develop vertical ridges, exactly as in *Castalina*: but in the anatomy these forms do not show the tendency to close the branchial opening in front. Also in the rest of the soft parts they remain upon the primitive *Diplodon*-stage.

We may express the affinities as follows:

```
Callonaia    Castaliella            Prisodon
       \      /                      /
       Castalia                  Hyria
              \                 /
                  Castalina
                      |
                  Diplodon
```

The genus *Diplodon* yet remains to be discussed. We have referred to it above as the most primitive type within the subfamily, and there are undoubtedly a number of species contained in it which have a primitive structure. But there are others which differ from them. The first question, however, to be considered is which characters we should regard as primitive.

As far as the shell is concerned, there is considerable variety within this genus.

Most of the species are subelliptical or subovate, and moderately elongated; but others approach more or less the suborbicular shape. For the latter, Simpson has introduced the subgenus *Cyclomya*, and it is true that these form a rather well-defined group, although there are certain species which seem to be intermediate.

The subquadrate or subtrigonal shape of the *Castalia*-group is unknown in *Diplodon*, and the well-defined posterior ridge characteristic of this group is very rarely found; the species, which have it, are always rather elongated (not trigonal), so there cannot be any mistake about them.

The hinge-teeth are also variable, but generally represent, or are easily compared with, the normal type described above (p. 459). There are one or two pseudocardinals and two laterals in the left valve, and two pseudocardinals and one lateral in the right valve. The pseudocardinals may be stumpy, or more or less compressed. They, as well as the laterals, may be smooth, or have corrugations, or may be split and dissected. They never have parallel ridges.

The beak-sculpture also varies a good deal. It is always radial, but the ridges composing it may be shorter or longer, finer or heavier, smooth, or dissected by growth-lines, granular, and sometimes they may be irregular.

But all of these characters of the shell are connected with each other by numerous transitions, and it is impossible to say that any one type is more primitive than another. It is also extremely difficult to arrange the species of *Diplodon* into groups according to these features. Simpson (1914 pp. 1225, 1228) has divided the genus into subgenera and subordinate groups, and has attempted to condense the results in the shape of a "key," but this key is practically worthless, of which fact anyone may convince himself, when he tries to use it for the identification of a species.

However, when I studied the soft parts of the various species at my disposal, I discovered that there are rather well-marked and apparently important *characters shown by the anatomy*, especially by the structure of the *marsupial part of the inner gill of the female*, while the rest of the anatomy is the same in all species.

The interlaminar connections of the gills are extremely weak in the male of *Diplodon*, and in the outer gill of the female (which has the same structure as in the male). They correspond to the description given by me for *Hyria* and *Castalia* (*Tetraplodon*) (Ortmann, 1911*a*, pp. 115, 117). (See the figures of gills of various species on Plates XLV, XLVI, XLVII; also sections of the gills on Plates XLVII and XLVIII). These interlaminar connections are few and scattered over the face of the gill, and do not form distinct septa (thus resembling the condition seen in the *Margaritanidæ*). But in the marsupial part of the inner gill of the female,

these connections become more frequent, are heavier, and stand closer together. Very often we see short connections grouped together either in a reticulate form, or in rows parallel to the gill-filaments, *ie.*, vertical to the edge of the gill (See text-figs. 1 and 2 *i*, on pp. 455–6), and it should be noticed that precisely the same arrangement is also seen in the Australian *Hyridella* (Ortmann, 1912, pp. 100–103, fig. 1). The connections of adjoining vertical rows may alternate in an irregular way, and may thus form irregular transverse or oblique rows. Towards the edge of the gill, and near the base, the connections are often somewhat elongated, stand closer together in the same row, and thus a more distinct arrangement into vertical septa is brought about, separating more distinct water-tubes (ovisacs), which, however, are laterally connected with each other by the interruptions of the septa (See Pl. XLV, figs. 1*b*, 2*b*, 3; Pl. XLVI, figs. 1, 2, 3, 4, 6, 7*a*, 7*b*; Pl. XLVII, fig. 1).

There is no doubt that the arrangement described above is primitive, for it most closely approaches the condition seen in the male gill. The marsupial structure is simply brought about by a more frequent and heavier development of the interlaminar connections of the male, which approach each other, and partly arrange themselves in vertical rows.

A step in advance is observed when the vertical rows prevail over the reticulate arrangement, and extend over the whole marsupial portion of the gill. Such cases are found, and in them the interlaminar connections may be shorter or longer, but they always stand close together in each row, so that we have all through the marsupium the appearance of distinct septa, which, however, are perforated by holes, so that the water-tubes (ovisacs) communicate with each other; this is most evident in *Diplodon piceus* (Pl. XLVI, fig. 2).

Furthermore in a few species (*D. decipiens*, Pl. XLV, fig. 4*b*, and *D. mogymirim*, Pl. fig. 5*c*; see also Pl. XLVII, fig. 7, and Pl. XLVIII, figs. 2*a*, 2*b*), I have observed a further advance in this structure. Here the septa become *solid, the interruptions are missing*, and each septum runs from the base of the gill vertically towards the edge, exactly in the manner which we know to be the characteristic condition in the *Unionidæ*. Well-defined water-tubes, which do not communicate, are thus formed. The species, which show this structure, have in the marsupial part of the gill hardly any indications of interruptions of the septa. In the non-marsupial portions, as well as in the outer gill of the female, and both gills of the male, the usual structure of *Diplodon* is present, showing few and scattered connections. This reveals that the solid septa of these species of *Diplodon* represent the highest stage in the marsupial development in this genus, and that this feature should not be considered as *homologous* to the septa of the *Unionidæ*. It is *analogous*, and has been independently acquired.

There are other differences in the marsupium of the species of *Diplodon,* and these depend upon its *location within the gill.* In the Australian *Hyridella* nearly the whole inner gill is marsupial, only very small portions at the anterior and posterior ends remaining non-marsupial, a very common condition in the *Unionidæ* where the whole outer gill may be marsupial. In *Diplodon* we sometimes observe a similar arrangement (*O. piceus,* Plate XLVI, fig. 2), but generally a more considerable part at the anterior as well as at the posterior end of the gill is non-marsupial, so that the marsupium is restricted to the middle portion (about half) of the gill. The marsupial part may become still more reduced in size, and may be located not in the middle of the gill, but more toward the front, or toward the posterior end. In either case the posterior or anterior half of the gill is nearly or quite non-marsupial. It should be noted that I have observed this shifting of the marsupial part only in cases where the marsupial structure is comparatively primitive, with the interlaminar connections arranged in a reticulate way or as interrupted septa, but never in forms with solid septa, where the marsupial part always extends over a large section in about the middle of the gill. (Compare figures on Pl. XLV, XLVI, XLVII.)

All these differences described in the structure and location of the marsupium are *constant within the species.* In some forms, indeed, my material is rather scanty; but in quite a number of other cases I have a sufficient number of individuals with soft parts, and I have invariably found that all females of the same form and from the same locality agree with each other, with the only qualification that in *young* females the marsupium is generally less extended, and occupies a smaller section of the gill (Compare Pl. XLVI, figs. 5*b* and 5*c*; Pl. XLVI, figs. 7*a* and 7*b*).

It should be emphasized that these marsupial differentiations are only found within the genus *Diplodon.* The other genera of which I have anatomical material stand generally upon the stages which I have described as the more primitive in *Diplodon.* Firstly the structure of the marsupium is of the reticulate type in the middle, with more or less development of interrupted septa towards the edges of the gill in *Hyria* (Ortmann, 1911*a*, p. 115) and *Castalia undosa* (*ibid.*, p. 117), while in *Castalina nehringi* the structure showing perforated septa prevails. *Castalia acuticosta* seems to agree with *C. undosa,* but my material consists of only two gravid, rather young specimens, in which the structure cannot be clearly seen on account of the mass of glochidia filling the marsupium. Secondly the location of the marsupium in *Hyria* and *Castalia* is in the middle of the gill (one-fourth at anterior end, less than that at posterior end, non-marsupial). In *Castalina nehringi* (Plate XLVII, fig. 2) the marsupium has moved a little more backward with about

the anterior half of the gill, and less than one-fourth of the posterior end non-marsupial.

Thus it is clear, that, while the *Castalia-Hyria*-group of genera in the shape of the shell and the hinge-teeth, and the *Castalia*-group in the conformation of the branchial openings represent a higher specialisation, in the rest of their anatomy, and chiefly in their marsupial characters, they all remain very close to the primitive *Diplodon*-type.

## The Glochidia.

(See Text-figure 4.)

In conclusion I may say that I have found differences in the glochidia within the genus *Diplodon*. That certain South American species of "*Unio*" have glochidia, was first announced by Lea in the case of *U. peculiaris* and *U. firmus* (Lea, Obs., XII, 1869, Pl. 34, figs. 80, 82; first published in 1868). He describes and figures them as subtriangular in outline, oblique, or upright, the ventral margin with a point, and in the text he says that they are "furnished with hooks." However, he neither describes nor figures these hooks.

Von Ihering (1893, p. 47) states that hooks are missing in all of the South American species examined by him, but that the larvæ are true glochidia.

This is about all we have known hitherto about the larval form of the South American "Unios" = *Hyriinæ*. I have now found that the normal shape (outline) of the glochidia of *Diplodon*, and of the subfamily *Hyriinæ*, is as described by Lea, namely subtriangular, with a point on the lower margin (see fig. 4). In addition, I have found that some species actually possess a "hook;" but this hook is entirely different from the one so well known in the European genus *Unio* and in the *Anodontinæ* of Eurasia and North America. The very fact that Lea mentions the hook in a kind of perfunctory way, not calling attention to its peculiar features, suggests that he never saw the real hook, and that he simply took the point of the lower margin of the glochidium for it.

This *Hyriine* hook (Fig. 4, *b, c, d, e, f, h, k, l, m*) differs entirely from the *Anodontine* hook. The latter is triangular, attached by a broad base to the point of the lower margin, and carries upon its upper surface a number of fine spinules. The *Hyriine* hook is long and narrow, spiniform, with very narrow base, articulated to the point of the lower margin, and without any spinules on the upper face, and furthermore has a peculiar S-shaped curve.

It is perfectly clear that this hook is different from that found in the genus *Unio* and the *Anodontinæ*. Functionally it may serve the same purpose, that of

forming attachment to fishes, but we have not the slightest direct evidence of this, and Von Ihering directly questions it (*l. c.*, p. 47). Morphologically this organ has been independently developed. It is *analogous* to the *Anodontine* hook, but not *homologous*.

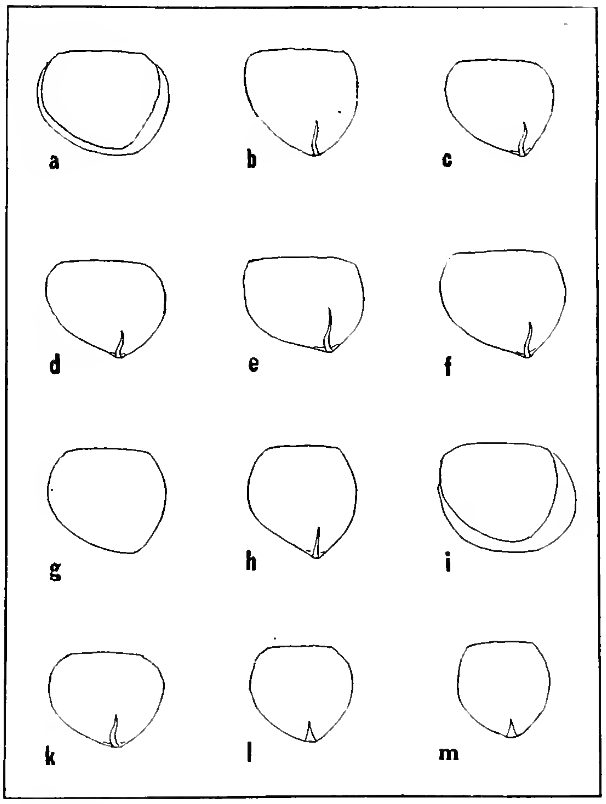


FIG. 4. Glochidia of *Hyriinæ*, enlarged fifty times (drawn from photographs).

*a. Diplodon hasemani* Ortmann (Rio Guaporé), from specimen No. 6. Cat. No. 61.5857.
*b. D. imitator* Ortmann (Santa Maria), from specimen No. 22. Cat. No. 61.9248.
*c. D. simillimus* Ortmann (Morretes), from specimen No. 2. Cat. No. 61.9250.
*d. D. vicarius* Ortmann (Aqua Quente), from specimen No. 9. Cat. No. 61.9251 (shell of this specimen figured on Plate XXXVI, fig. 2).
*e. D. decipiens* Ortmann (Serrinha), from specimen No. 10. Cat. No. 61.9253.
*f. D. paulista* (Von Ihering) (Mogy Mirim), from specimen No. 10. Cat. No. 61.9256.
*g. D. charruanus* (D'Orbigny) (Santa Isabel), from specimen No. 5. Cat. No. 61.5861.
*h. D. piccus* (Lea) (Uruguayana), from specimen No. 1. Cat. No. 61.5862.
*i. D. hildæ* Ortmann (Cachoeira), from specimen No. e. Cat. No. 61.5864.
*k. D. mogymirim* Ortmann (Mogy Mirim), from specimen No. 48. Cat. No. 61.9260.
*l. Castalina nehringi* Von Ihering (Salto das Cruzes), from specimen No. 1. Cat. No. 61.5119.
*m. Castalia acuticosta* Hupé (Rio Guaporé), from specimen No. 1. Cat. No. 61.5112.

I have said that only some *Hyriinæ* have this hook. I found it in the case of several species of *Diplodon*, in *Castalina nehringi*, and *Castalia acuticosta*, and it

should be mentioned at this point that these hooks appear only in the fully developed glochidium, while in younger, immature glochidia they are lacking.

But it seems that in certain species of *Diplodon* the hooks are always absent, and in these cases the glochidia fully resemble the figures given by Lea. Of course, in certain cases it is hard to decide whether the glochidia are fully developed, or whether the absence of hooks may be due to the immature condition of the individual. However, I have a case in which I believe I am justified in thinking that the glochidia, when fully developed, have no hooks. In three gravid females of *D. charruanus*, the glochidia were all alike, and no hooks were observed (Fig. 4*g*). One of these apparently was discharging, and thus we should expect mature glochidia (unless this were a case of premature discharge).

In a few other cases I am sure that mature glochidia have no hooks, since they are surrounded around the whole lower edge, with a margin, which possibly represents the first beginning of the permanent shell of the adult (Fig. 4*a, i*). In other groups of *Naiades*, with one exception (*Anodonta imbecillis* Say of North America), nothing of the kind is known in glochidia, as long as they remain within the marsupium, and also in these South American forms, when immature, the glochidia do not possess this margin. I never have seen a trace of hooks here. The margin has much the appearance of that formed in young North American *Unionidæ*, after the parasitic stage on fish.

That in these cases the shell should appear at so early a stage, when the larva is still within the marsupium of the mother, is indeed remarkable, and possibly points to the conclusion that the modes and conditions of embryonic development in the *Hyriinæ* differ considerably from those of the *Unionidæ*.

If the above observations are correct, we would have *three types* of glochidia in the genus *Diplodon:* (1) Of triangular shape, with hooks; (2) Of the same shape, without hooks; (3) Of the same shape, and without hooks, but with a margin around the lower edge, which obliterates the triangular shape.

Whether the second group is real, or only due to incomplete observation, or passes finally into the third, remains to be seen. At any rate, it is very desirable that close attention should be directed to this question in future work on South American *Naiades*.

The size of the glochidia is comparatively large, varying from 0.20 to 0.35 mm., which might be called a good medium size in comparison with the glochidia of the *Unionidæ*.

I regret that my observations on the glochidia of the *Hyriinæ* are not more satisfactory. There are indications of important differences, but for the present

we must be satisfied with having pointed out this fact, and with hinting that perhaps further knowledge of the glochidia may furnish at least some criteria for a classification of the species of Diplodon. The same remark holds good of the marsupial structure. In reference to this we possess a little more knowledge, but it is still too scanty to make an attempt to use it for classification. The genera with the specialized shells of the *Castalia*- and *Hyria*-groups are well defined, but their anatomy and their glochidia do not present any remarkable differentiations, except the structure of the branchial opening in the *Castalia*-group. On the other hand, it appears that the genus *Diplodon* may finally prove to be composed of an aggregation of more varied forms than heretofore supposed, and that the distinctive characters of these are found chiefly in the marsupium and the glochidium.

We may perhaps distinguish within the old genus *Diplodon* a type, which we might regard as having the more primitive features, such as a marsupium composed of interrupted or reticulated septa, occupying the whole or nearly the whole of the inner gill, and probably one of the types of glochidia above described. But it is hard to say, which form this is. I am inclined to regard the hooked glochidium as the more primitive form. The margined glochidium certainly represents a more advanced type. It might finally be possible to split up this genus into smaller genera, one of which should contain these primitive forms, the others to include forms more advanced in regard to their marsupial structure and glochidia. But in the present state of our knowledge this step cannot be taken, and we must be satisfied with an arrangement of the species based upon the characters of the shells.

## The Species of the Hyriinæ.

### Genus Diplodon Spix (1827).

*Diplodon* Spix, 1827, p. 33 and plate 26.—Diplodon Simpson, 1900, p. 872; 1914, p. 1224.[11]

*Type of genus:—Diplodon ellipticum* (*ellypticum* err. typogr.) Spix, 1827, Pl. 26, figs. 1, 2. (Same type given by Simpson, 1900.)

### The Subdivisions of the genus Diplodon.

Simpson (1914, p. 1225) has made an attempt to divide this genus into subgenera and groups. But he also included in it Australian species under the subgenus *Hyridella* Swainson, which we now regard as a separate genus, and an African

[11] *Diplodon*, as accepted by H. & A. Adams (1858, p. 497) as a subgenus of *Unio*, is an entirely heterogenous association of species, including forms from all over the world.

form (Subgenus *Lævirostris* Simpson), which we may with considerable confidence assume does not belong here, until the contrary has been positively demonstrated.

Thus restricted, the genus *Diplodon* from our point of view falls in Simpson's arrangement into two subgenera, *Diplodon* (Simpson, 1914, p. 1226) and *Cyclomya* (Simpson, 1914, p. 1278), each subdivided into groups. The characters of the shells of these groups run into each other very insensibly, and are found in various combinations. The subgenus *Cyclomya* is somewhat better defined, inasmuch as the rounded outlines of the species assigned to it contrast rather markedly with most of the elliptical, somewhat elongated shells, assigned by Simpson to typical *Diplodon*. But there are intergrades even here. Typical *Cyclomya* (of the *funebralis*-type) is irregularly circular, with rounded angles (obscurely pentagonal), and has a short and high shell, with the greatest height situated in the middle of the shell, at about the middle of the ligament. Simpson included in it as species *fontainianus*, and *gratus*, which I regard only as higher and shorter forms belonging to *Diplodon*. They have the greatest height of the shell not in the middle, but more posteriorly, behind the ligament, and thus their outline is distinctly oblique and subtrapezoidal, although approaching the rounded shape.

Simpson, indeed, says in addition, that the beak-sculpture in typical *Diplodon* consists of "unbroken ridges," and that in *Cyclomya* it is "irregularly radial." In both cases this holds good only for certain species, and cannot be used as a generally distinguishing character.

### Subgenus Diplodon Simpson.

Simpson, 1900, p. 873; 1914, p. 1226.

Shell more or less elongated; elliptical, ovate, or subtrapezoidal in outline; when short, more or less angular and distinctly oblique, with the greatest height behind the ligament, but not subcircular with the greatest height under the ligament.

The arrangement into groups, as here given, does not rest upon that of Simpson. It is largely made to suit my material, and does not claim to be final. We may express the essential differences in the following key, but with the distinct understanding that there are transitions between the groups, which are hard to place.

#### Key to Groups in Genus Diplodon.

*a.* Shell straight, not oblique, *i.e.*, the longest axis is nearly parallel to the ligament.

*b.* Beak-sculpture covering a considerable part of the disk; ridges, chiefly the posterior, rather heavy. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Group of D. hylæus.*

*bb.* Beak-sculpture more or less developed, rarely covering a considerable part of the disk; ridges not very heavy and rather uniform.

*c.* Beak-sculpture well-developed, fine; ridges cut up into fine nodules. . .*Group of D. granosus.*

*cc.* Beak-sculpture restricted to the region of the beaks; ridges fine, simple, not granular.

*d.* Shell rather compressed and flattened upon the sides, subtrapezoidal in outline, and not distinctly pointed behind. . . . . . . . . . . . . . . . . . . . . . . . . . . . . .*Group of D. chilensis.*

*dd.* Shell slightly or not at all compressed, convex upon the sides, mostly subelliptical or subovate in outline, more or less pointed behind.

*e.* Shell rather elongate, not high, subelliptical or subovate. . .*Group of D. charruanus.*

*ee.* Shell shorter and higher, subovate or subtrapezoidal. . . . . . . .*Group of D. lacteolus.*

*aa.* Shell distinctly oblique, with the longest axis forming an angle with the line of the ligament. Outline subovate or subtrapezoidal, sometimes rather high and short. . . . . . . . . . . . . .*Group of D. ellipticus.*

### 1. Group of *Diplodon hylæus.*

Shell subelliptical, subovate, or subtrapezoidal, more or less pointed posteriorly, straight, not distinctly higher behind, nor oblique. Beak-sculpture well-developed, covering a considerable (but variable) part of the shell; bars rather heavy; those upon, and immediately in front of, the indistinct posterior ridge of the shell are heavier and longer than the rest; one or two of the median bars joining at their lower ends; sometimes the bars are somewhat nodulous (but not granular).

The beak-sculpture is the most essential feature of this group. Additional, but subordinate, characters are found in the hinge-teeth, chiefly the larger ones in each valve, which are triangular, rather thick, ragged, but not compressed. Often there are two pseudocardinals in the left valve.

I have seen the female soft parts of two species, *D. hasemani* and *trifidus.* In both the marsupial part of the inner gill is located in the middle section and has interrupted septa. The former species has the margined type of glochidium. It seems that this group is not very primitive.

### 1. Diplodon hylæus (D'Orbigny).

*Unio hylæa* D'Orbigny, 1835, p. 36; 1843, p. 607, Pl. 69, figs. 8, 9.
*Unio hylæus* Sowerby, XVI, 1868, Pl. 93, figs. 506 *a* and *b* (poor figures).
*Margaron (Unio) hylæus* Lea (*pro parte*), Syn. 1870, p. 31.
*Unio hylæus* Von Martens, 1894, p. 164.
*Diplodon hylæus* Simpson (*pro parte*), 1900, p. 884; 1914, p. 1274.

*Type-locality.*—"Rio Palometas, Rio Pari, and Rio Tucabaca, in the provinces of Santa Cruz de la Sierra and Chiquitos, in Bolivia."

I have been unable to locate the first two rivers; a *Rio Tucaraca,* in the Chiquitos country (Prov. Santa Cruz de la Sierra in Bolivia), runs to the Paraguay River, and I have no doubt that this river was intended, and it is advisable to take this as the type-locality.

*Other localities.*—Von Ihering (1893, p. 119) gives this species from Rio Paraguay, but also upon D'Orbigny's authority,[12] from the Amazon-drainage. Von Martens (*l. c.*) reports it from Paraguay. No other localities have been hitherto cited.

*New locality.*—Rio Paraguay, São Luiz de Caceres, Matto Grosso, Brazil, (J. D. Haseman coll., May 25, 1909). One specimen.

*Distribution.*—The new locality is not very far from the type-locality (Rio Tacaraca), about 400 kilometers up the river, and demonstrates that this species belongs to the upper Paraguay drainage in Bolivia and western Brazil. According to Von Martens it goes down this river to Paraguay.

*D. hylæus* and *guaranianus* have been united by Lea, Sowerby, and Simpson, but I think that this is not correct, and that I have both species before me, agreeing well with D'Orbigny's remarks about them. The real *D. hylæus* is a larger shell, with the lower posterior end somewhat more produced, and with differences in the beak-sculpture, which extends over a larger section of the shell, and consists of rounded bars, which are somewhat irregular, and are rugose or slightly nodulous. The figure of D'Orbigny (Fig. 8) shows the sculpture very well.

I have only a single individual of this species, without soft parts, and have drawn the following description from this.

*Description of Shell.*—Shell comparatively small, moderately solid, subovate or subtrapezoidal, slightly higher behind. Height 64 pr. ct. of length. Dorsal margin very gently curved, passing into the posterior margin in a blunt, rounded angle. Posterior margin obliquely descending, emarginated, but this emargination undoubtedly is an individual feature, since the growth-lines indicate that it was not present, when the shell was younger. Lower posterior angle slightly produced, but rounded. Lower margin with its lowermost part placed at between two-thirds and three-fourths of the length of the shell (from anterior end), curving up behind. In the anterior portion it slopes upward in an almost straight line, finally curving up into the anterior margin; thus the shell appears slightly narrower in front than behind.

Valves rather flat (in this respect my specimen differs from the original *hylæus*, which is more convex), gently and rather uniformly convex, with the umbonal (posterior) ridge weakly marked, and indicated chiefly by a shallow radial depression upon the posterior slope, which forms the emargination at the posterior margin, and makes the posterior ridge appear slightly biangulate towards the

[12] He says that all forms reported by D'Orbigny from Bolivia are from the Amazon-drainage. In this particular case this is not correct, since the Rio Tucaraca of Bolivia drains into the Paraguay.

posterior end. Diameter of shell 33 pr. ct. of length. Beaks not swollen, and not prominent, located at about one-fourth of the length from the anterior end.

Beak-sculpture strongly developed, covering about half of the disk, the longest bars (near the umbonal ridge) are about 20 mm. or more long. There are about sixteen or seventeen radial bars, of which the ninth and tenth, and the eighth and eleventh, unite in sharp angles, and between the ninth and tenth, there is a short odd bar, which is indistinct on account of the erosion of the beaks. Posteriorly the bars increase in length as well as thickness: the anterior bars are comparatively sharp, narrow, but much injured in my specimen; the posterior bars are broader and rounded. Upon the umbonal ridge, the radial bars are again finer, and upon the posterior slope there are four or five additional fine bars, which are shorter, and restricted to the upper part of the slope. On the lower part of the latter, there are a number of fine, irregular, oblique wrinkles. The lower ends of the radial bars are cut up, chiefly near the umbonal slope, into irregular, low tubercles, and traces of such tubercles may be seen near the lower margin of the shell. No distinct lunula is seen in our shell, but this part of the shell is badly eroded.

Epidermis with numerous, irregular, concentric wrinkles, and traces of radial lines. Color brown, much like that of D'Orbigny's figure.

Hinge-line gently curved. Ligamental sinus over the posterior fourth (or a little more) of the lateral teeth, which are gently curved, one in the right, two in the left valve. Pseudocardinals directed obliquely forward and downward, two in right valve, the anterior one narrow, low, and compressed, the posterior one triangular, cut longitudinally into two parts. In the groove behind this tooth, the hinge-line has two small denticles. In the left valve, there are two pseudocardinals, the anterior subtriangular, slightly compressed and simple, fitting into the groove between the two teeth of the right valve, the posterior one broader, and cut into three parts. Leaving out of sight the comparatively stumpy and double character of these teeth, their finer structure can only be regarded as an individual characteristic.

Cavity of shell and beaks shallow. Nacre whitish (discolored in the cavity). Anterior adductor-scar distinct, subelliptical; anterior retractor-scar separated from it, small, round and deep; anterior protractor-scar connected with the adductor-scar. Posterior adductor-scar faint, subovate, with an upper triangular process formed by the posterior retractor-scar. Mantle-line faint. Dorsal muscle-scars in the cavity of the beaks.

MEASUREMENTS.

| | Length. | Height. | Diameter | Beaks. |
|---|---|---|---|---|
| My specimen | 42 mm. | 27 mm. = 64 pr. ct. of L. | 14 mm. = 33 pr. ct. of L. | at 10 mm. = 24 pr. ct. of L. |
| D'Orbigny's figure | 43 " | 25 " = 58 " | 16 " = 37 " | 8 " = 19 " |
| Do., in text | 45 " | 60 " | 40 " | |

*Remarks:* The chief characters of this species, so far as I am able to make them out from the figure and description, and the single specimen at hand, by which it differs from the other species of this group, are found in the general shape (moderately elongated, slightly wider behind, with rounded posterior angle), the beak-sculpture, which covers a rather large portion of the disk, and the rough character of the posterior slope. The greater compression of our shell probably is individual, and also the emargination of the posterior margin.

## 2. Diplodon guaranianus (D'Orbigny).

*Unio guaraniana* D'Orbigny, 1835, p. 37; 1843, p. 608, pl. 69, figs. 10–12.

*Type-locality.*—Rio Parana, Itaty, Province of Corrientes, Argentina. No other locality previously known.

*New Localities.*—Paraguay River, Corumbá, Matto Grosso, Brazil (H. H. Smith coll.). One specimen, juv. In swamps of Lambaré, near R. Paraguay, Asunción, Paraguay (J. D. Haseman coll. March 31. 1909). One complete specimen, 6 left valves. Rio Paraguay, São Luis de Caceres, Matto Grosso, Brazil (J. D. Haseman coll. May 25, 1909). One male, with soft parts, and seven specimens, shells only.

*Distribution.*—Middle Paraná above the junction with the Paraguay River in Argentina and Paraguay, and Paraguay River through Paraguay as far as Matto Grosso, Brazil.

I disagree with previous authors, and regard this species as being distinct from *D. hylæus.* My specimens answer very well to the description and figures of D'Orbigny, and they differ from *hylæus* in their somewhat smaller size, in the more distinctly truncated (more steeply descending) posterior margin, forming a more distinct lower posterior angle, but chiefly in the beak-sculpture, which consists of a smaller number of bars, which are heavier, chiefly posteriorly, and are not so rugose. My specimens are also more swollen than the single individual of *hylæus* at hand, but the latter is, as has been stated, probably exceptional in this.

The beak-sculpture is somewhat variable, chiefly in the length of the bars, which are from 15 to 20 mm. long, and generally cover more than half of the disk, but in the larger shells, sometimes less. There are twelve to fourteen radial bars,

of which the seventh and eighth, or ninth and tenth, unite in the middle of the valve in a sharp angle; sometimes a short odd bar is found between these pairs. The bars are rather fine and sharp in front, but those behind, near the umbonal ridge become broad and rounded, their lower ends being irregular and indistinctly tubercular (much less so than in *D. hylæus*) occasioned by concentric lines cutting across them. These posterior bars also are distinctly longer than the anterior ones. Sometimes there are a few additional fine bars near the beaks on the posterior slope and below them a few oblique wrinkles.

The posterior end of the shell is also somewhat variable, but it never is rounded and slightly biangular, as it is in *D. hylæus*. The posterior margin is obliquely descending, and the lower posterior end is bluntly pointed, the angle being more or less prominent. The lower margin of the shell is evenly convex in some specimens, in others it is more strongly convex a little back of the middle, forming a blunt angle.

The specimen from Corumbá is young, and the beak-sculpture covers all of the shell. It is also a little more compressed than the others, but agrees with them in all other characters.

MEASUREMENTS.

| | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|
| Asunción, No. 1 | 21 mm. | 14 mm. = 67 pr. ct. of L. | 10 mm. = 48 pr. ct. of L. | at 4 mm. = 19 pr. ct. of L. |
| Do. 2 | 27 " | 18 " = 67 " | 14 " = 52 " | 6.5 " = 24 " |
| Do. 3 | 28 " | 19 " = 68 " | 13 " = 46 " | 7 " = 25 " |
| Do. 4 | 33.5 " | 22 " = 66 " | 13 " = 39 " | 8 " = 24 " |
| S. Luis d. C. (♂) | 39 " | 24 " = 62 " | 15.5 " = 40 " | 8 " = 21 " |
| D'Orbigny's fig. | 32 " | 19 " = 59 " | 12 " = 38 " | 8 " = 25 " |

Thus my specimens are on the average slightly higher and shorter, and somewhat more swollen than the original, unless there are inaccuracies in the figure, which is not impossible, since the figure is 32 mm. long, while the text gives the length as 21 mm.

*Anatomy.*—The only specimen (S. Luis de Caceres) of which soft parts are at hand, is a male, and has the structure typical of the genus. The anal opening is slit-like, and about three-fourths of the length of the branchial. The branchial opening has fine papillæ. The palpi are triangular and rather small, the posterior margins are not connected. Inner lamina of inner gills connected with abdominal sac. Gill-structure typical.

### 3. Diplodon hasemani Ortmann, sp. nov.

Pl. XXXIV, figs. 1 to 4, shells; Pl. XLVII, fig. 5, section of gills; text-fig. 4*a* (p. 469), glochidium.

*Locality.*—Rio Guaporé, near Rio São Simão, Matto Grosso, Brazil (John D. Haseman coll., July 20, 1909). Nineteen specimens investigated, all with soft parts; sex of the three smallest not ascertained; the rest were males and gravid females.

*Type-set:* Carn. Mus. No. 61.5857, twelve specimens, among them four males and five gravid females, one with eggs, the others with glochidia.

*Description of Shell.*—Shell small (max. length 28 mm.), solid, swollen, short, subovate, somewhat pointed behind. Diameter 67 to 72 pr. ct. of length, as against 59 to 68 pr. ct. in *D. guaranianus.* Valves not gaping. Dorsal margin gently convex, passing gradually or with a blunt angle into the anterior margin, which is sometimes almost truncated. The posterior upper margin forms an obtuse, rounded angle with the posterior margin, the latter descending obliquely, gently convex, forming with the lower margin a rather distinct, but blunt posterior termination of the shell, which is little elevated above the base-line. Lower margin gently and uniformly convex, passing in a regular curve into the anterior margin. The anterior portion of the shell does not appear appreciably narrower than the posterior, or very little so.

Valves convex, more so in older specimens, with a rather distinct, but rounded umbonal ridge. Posterior slope subtruncated, a little compressed and elevated in the middle. Greatest diameter of shell 42 to 55 pr. ct. of length (32 to 52 pr. ct. in *D. guaranianus*). This greatest diameter located more forward toward the beaks than in *D. guaranianus.* Beaks somewhat swollen, but little elevated above the hinge-line, located at 25 to 28 pr. ct. of the length. Beak-sculpture of the *hylæus*-type, strongly developed, the posterior bars thicker and longer than the anterior. They cover 10 to 15 mm. of the shell, that is to say, hardly half of it in larger specimens. There are from fourteen to sixteen of them, and the ninth and tenth generally meet at an acute angle, with sometimes a short odd one between this pair. The anterior bars are sharp, the posterior ones broader and rounded, but not so much as in *D. guaranianus.* There are often three or four additional finer bars upon the posterior slope, and some oblique wrinkles behind and below them. The lower ends of the bars are but faintly cut up into tubercles. A lanceolate, rather short, lunula may be present in the larger specimens.

Epidermis with numerous, concentric, irregular striæ, finely lamellar in young

specimens, and in older specimens on the posterior slope and toward the lower margin. Fine, obscure, radial lines all over the shell. Color rather uniformly dark brown, but in young specimens there is a distinct indication of a yellowish concentric band, or the region near the beaks may be of this color (suggesting the color-pattern of *D. trifidus*).

Hinge-line gently curved. Ligamental sinus over the middle of the lateral tooth, or a little farther back. Lateral teeth curved, one in right, two in left valve. In one specimen in the right valve there is a distinct, but low, accessory lateral below the normal one. As a rule two pseudocardinals in each valve. They are not much compressed and not much elongated, but rather stumpy, and are very much cut up, especially the posterior ones in each valve. The anterior pseudocardinal in the right valve is more distinctly compressed, but may be very small or even obsolete, and there may be a trace of a third pseudocardinal behind. The posterior pseudocardinal in the left valve is very variable in shape and size.

Cavity of shell and of beaks moderate. Nacre in all specimens whitish. Anterior adductor-scar deep, even in young specimens, irregularly rounded. Anterior retractor-scar separated from it, small and deep. Anterior protractor-scar united with the adductor-scar. Posterior adductor-scar less distinct, subtriangular, with a short upper process formed by the posterior retractor-scar. Pallial line distinct. Dorsal scars few, located in beak-cavity and close to hinge-plate.

Measurements.

| No. | Sex. | Length. | Height. | Diameter. | Beaks. | Figures. |
|---|---|---|---|---|---|---|
| 1... | ? | 12.5 mm. | 9 mm. =72 pr. ct. of L. | 5.5 mm. =44 pr. ct. of L. | at 3.5 mm. =28 pr. ct. of L. | |
| 2... | ? | 15 " | 10 " =67 " | 7 " =47 " | 4 " =27 " | |
| 2*a*.. | ♂ | 18 " | 13 " =72 " | 7.5 " =42 " | 5 " =28 " | |
| 4... | ♀ | 23 " | 16 " =70 " | 11 " =48 " | 6.5 " =28 " | Pl. XXXIV, fig. 3. |
| 6... | ♀ | 25.5 " | 17 " =67 " | 12 " =47 " | 7 " =27 " | |
| 7... | ♂ | 26 " | 18 " =69 " | 14 " =53 " | 7 " =27 " | |
| 9... | ♀ | 28 " | 19.5 " =70 " | 14 " =50 " | 7 " =25 " | Pl. XXXIV, fig. 2. |
| 10... | ♂ | 27.5 " | 20 " =72 " | 15 " =55 " | 7 " =25 " | Pl. XXXIV, fig. 1. |

I cannot discover any sexual differences in the shell.

*Remarks.*—There is no question that this species is very closely allied to *D. guaranianus*, and it may be described as a small, short, rather swollen *D. guaranianus*, with the posterior end of the shell a little sharper, the posterior ridge a little more distinct, and beak-sculpture less developed. Since I possess a good number of specimens of *D. hasemani*, and also a fair number of *D. guaranianus*, I do not doubt the specific distinctness, since the geographical distribution also differs. *D. guaranianus* belongs to the Paraná and Paraguay Rivers, while *D. hasemani* is from the Guaporé, tributary to the Amazons-system. However, a former connection of these systems is indicated by the close affinity of the two species.

*Anatomy.*—I have before me many males and gravid females with soft parts. It should be noted that the smallest gravid females are only 16 mm. long and that this fact indicates that this is a small species, not growing to a larger size, as my material shows, reaching the maximum length of 28 mm.

Anal opening short, slightly shorter than the branchial opening, the latter very short, with few but distinct papillæ. Palpi subtriangular, lower margins convex, posterior margins scarcely connected. Gills normal. Inner lamina of inner gill entirely connected with abdominal sac. In the larger gravid females the middle of the inner gill is marsupial, leaving a little less than one-fourth of the gill both at the anterior and posterior ends non-marsupial. In the smaller females the marsupial part is smaller. The swelling of the charged marsupium is moderate and the gills are charged to near the edge. In the marsupial part the interlaminar connections are arranged in interrupted vertical septa. Since no sterile females are at hand, the exact arrangement could not be seen in a face view, but from sections (Plate XLVII, fig. 5) it is evident that it is very likely more or less reticulate.

*Glochidia* (Text-fig. 4*a*, p. 469) subtriangular and margined, without hooks. Measurements, without margin: L. 0.30 to 0.31 mm.; H. 0.24 to 0.25 mm.; with margin: L. 0.35 to 0.36 mm., H. 0.29 to 0.30 mm. The presence of eggs and glochidia on July 20 should be recorded with respect to the breeding season.

*Color of Soft Parts in Alcohol.*—Foot blackish in its distal part, this color separated in a sharp line from the light basal part. Rest of soft parts whitish.

### 4. Diplodon trifidus (Lea) (1860).

*Diagram of Soft Parts* (*See* Text-fig. 1, p. 455).

*Unio trifidus* Lea, Obs. X, 1863, Pl. 44, fig. 295.

*Diplodon trifidus* Simpson, 1900, p. 884; 1914, p. 1272.

*Type-locality.*—"Buenos Ayres." Never reported again since its original description.

*New Localities.*—Centre of Rio Guaporé, near Rio São Simão, Matto Grosso, Brazil (J. D. Haseman coll., July 20. 1909). Six specimens, all with soft parts. In the three smallest the sex is uncertain (they have the male structure); the others are two males and one (the largest) a gravid female with eggs. Rio Guaporé, São Antonio de Guaporé, Matto Grosso, Brazil (J. D. Haseman coll., July 31, 1909). One male with soft parts.

*Distribution.*—I have doubts as to the correctness of the locality originally given. Von Ihering (1893, p. 118) lists this species with those from the La Plata drainage, but he rests entirely upon Lea. The latter received his single specimen

from D'Orbigny with the above locality; but it is quite possible that a mistake was made, since D'Orbigny also collected in the Amazon system in Bolivia, in the general region, whence our specimens come. Nobody else ever re-discovered this species in the La Plata, although frequent collections have been made. Our material is beyond any doubt this species, and the locality is authentic.

The set, although containing only six specimens, comprises young and old, males and females, and thus it is worth while to give a full description.

*Description of the Shell.*—Of medium size, growing larger than any of the preceding species (maximum length 58 mm.; the type is 42 mm., according to Simpson), rather solid. Outline subelongated, subelliptical, or long-ovate, rounded in front, pointed behind. Height 41 to 54 pr. ct. of length. Valves not gaping. Dorsal margin straight in young specimens, very gently curved in older ones. Anteriorly the dorsal margin forms an indistinct angle with the anterior margin in young individuals; in old ones it passes into it gradually. Posteriorly the dorsal margin forms a very obtuse angle with the posterior margin, or, in the largest specimen, passes gradually into it in a gentle curve. Posterior margin obliquely descending, gently curved, meeting the posterior portion of the lower margin in a blunt, but distinct, point, which is elevated above the base-line, but nearer to the latter than to the line of the upper margin. Ventral margin gently and rather regularly convex, its lowest point slightly behind the middle of the shell, ascending in front and behind it. In front it curves up into the anterior margin. Thus the shell has a long-ovate, almost subelliptical outline, with the anterior end only slightly narrowed and rounded, and the posterior more tapering and bluntly pointed.

Valves moderately convex, convexity rather uniform all over the disk, but strongest near the beaks and upon the umbonal ridge, which forms a rounded, but rather distinct, angulation running toward the posterior point. Posterior slope somewhat compressed. Diameter 23 to 36 pr. ct. of length. Beaks not swollen, hardly elevated above the hinge-line, located at 18 to 25 pr. ct. of the length. Since the shell is more swollen towards the beaks, the latter appear depressed, chiefly in old specimens. Beak-sculpture distinct and well developed, consisting of about sixteen radial bars; the anterior bars are shorter (about 5 mm. long), the posterior much longer, chiefly upon the umbonal ridge, where they are 15 mm. long, or even more. There are two systems of these bars; eight or nine anterior, and seven or eight posterior bars. In the middle of the shell one or two pairs unite at a sharp angle, and sometimes a short, odd bar stands between the innermost pair. The anterior bars are sharp; the posterior ones are also rather sharp near the beaks, but towards their lower ends they gradually become thicker and rounded, broaden-

ing and flattening, and finally disappearing. These broad bars are conspicuous chiefly immediately in front of the umbonal ridge, and are distinctly seen even in our largest specimens, where the beaks are greatly eroded. All these bars are smooth, except for the concentric striæ of the epidermis which cut across them. In some of my young specimens there are a few oblique wrinkles upon the posterior slope, but there are hardly any radial bars, except one, fine, and short, close behind the broad bars of the umbonal ridge. There is a narrow and short lunula in front of the beaks.

Epidermis smooth, but with numerous, irregular, concentric lines, which become sublamellar upon the posterior slope and near the lower margin. There are also numerous fine, irregular, but straight, radiating lines on the disk below the beak-sculpture. The posterior slope has no radial ridges or furrows. Color of epidermis dark to light green, with concentric bands of yellow-brown. The three young specimens are light golden-brown towards the beaks, and light green towards the margins; in the old specimens the green color prevails, and becomes quite dark, but is interrupted by one or two lighter bands of brownish. No traces of color-rays present.

Hinge-line almost straight or very gently curved. Ligamental sinus over the posterior third of the lateral teeth. One lateral in the right, two in the left valve, rather long, distinct, and in old shells gently curving downward behind. Pseudocardinals very variable. Lea describes them as trifid in both valves, but this is not always the case. Of our largest specimen it may be said that the right valve has three teeth: the middle one the largest, directed obliquely downward and forward, triangular, narrow above, broader below, and deeply longitudinally cleft into three ridges; in front of it is an anterior, narrow, compressed tooth, which is connected with the middle one above; behind the largest pseudocardinal is a deep groove, followed by small, ragged elevation of the hinge-plate representing the third tooth. The left valve has one large posterior tooth, which is ragged and fits into the groove behind the middle tooth of the other valve (including the small elevation behind it), and in front of it is a narrow lamellar tooth, fitting into the space between the first and second teeth of the right valve. In the groove between these two teeth of the left valve are two low ridges, corresponding to the clefts of the large tooth of the right valve. In our second largest specimen (No. 1) the same general arrangement is seen, but the anterior tooth of the right valve is very low, while the third (posterior) is more distinct and triangularly elevated. The left valve has two teeth. All these teeth are much less ragged, and the clefts of the middle tooth of the right valve are lacking, and also the corresponding ac-

cessory ridges of the left valve. Similar, but rather variable, conditions are seen in the younger individuals and the specimen from S. Antonio. The rule is that there are three teeth in the right, but only two in the left valve.

Cavity of the shell moderate, that of the beaks shallow. Nacre shining, snow-white in my specimens, in two (No. 1 and the one from S. Antonio) with a faint salmon blush in the cavity of the shell. Anterior adductor-scar deeply impressed even in young specimens, irregularly rounded or broadly subelliptical. Anterior retractor-scar located above it, separated from it, deep, small. Anterior protractor-scar connected with it. Posterior adductor-scar distinct, but much less impressed, subovate or subtriangular, with a rounded or triangular appendix above, formed by the posterior retractor-scar. Pallial impression distinct. Dorsal scars five or six, in cavity of beaks, placed irregularly, or in an oblique line.

There are no sexual differences in the shell.

Measurements (specimens from São Simão).

| No. | Sex. | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|---|
| *a*........ | ? | 21.5 mm. | 9 mm. = 41 pr. ct. of L. | 5 mm. = 23 pr. ct. of L. | at 4.5 mm. = 21 pr. ct. of L. |
| *b*........ | ♂ | 34 " | 16 " = 47 " | 10 " = 29 " | 7 " = 21 " |
| 1........ | ♂ | 56 " | 30 " = 54 " | 17 " = 30 " | 14 " = 25 " |
| 2........ | ♀ | 58 " | 29 " = 50 " | 21 " = 36 " | 14 " = 24 " |
| Lea's figure...... | | 42 " | 22 " = 52 " | 15 " = 36 " | 7.5 " = 18 " |

In Lea's text there is apparently an error with respect to the height, since the measurement would yield the absurd figure of 89 pr. ct. of the length. According to the figure Lea had a specimen with the beaks a little more anterior than any of mine, but otherwise rather closely agreeing with them.

*Remarks.*—This species is related to those of the *hylæus-group*, chiefly to *D. guaranianus*, but it is easily distinguished by its long-ovate shape, with pointed posterior end, and by the beak-sculpture, which, although of the same type, does not extend so far upon the disk. A good character is furnished also by the color of the epidermis and its concentric bands, though we have seen that this pattern is at least indicated in young *D. hasemani*. Lea compares *D. trifidus* with *D. burroughianus* and *parallelopipedon*, but there hardly is any close relationship to the former, and but a superficial resemblance to the latter. I think it belongs to the *hylæus-group*, and may be characterized as an extremely elongated member of that group, in which the beak-sculpture is not quite so fully developed as in the other species.

*Anatomy* (Text-fig. 1, p. 455).—The three smallest of my specimens could not be satisfactorily examined to ascertain the sex, but the gills did not show the mar-

supial structure, so that they may be males. Of the others, three are males, and one is a gravid female with eggs. The fact that this was collected on July 20 gives an indication of the breeding season.

Anal opening (*a* in text-figure) closed above, without forming a supra-anal. Closed part (*s*) two to three times as long as the anal; the latter (*a*) slit-like, short, shorter than the branchial opening. Inner edge of anal practically smooth. Anal separated from the branchial by a solid bridge (*t*). formed by the union of the mantle-margins. Branchial opening (*b*) a little over twice as long as the anal, with distinct papillæ on inner edge; mantle-edges not united in front of it. Palpi (*h*) subtriangular, the lower margins slightly convex, the posterior margins connected at the base.

Gills (*i* and *o*) rather long and moderately wide. The inner (*i*) wider than the outer (*o*) chiefly in front. Outer gill narrowing behind and before, its anterior end near the highest point of the mantle-attachment-line. The inner gill has an almost straight lower margin, and is only little narrower anteriorly; its anterior end is immediately behind the palpi. Inner lamina of inner gill entirely connected with abdominal sac.

Structure of gills normal. In the male both gills have fine, scattered, and interrupted interlaminar connections, running parallel with the gill-filaments, but without forming complete septa or water-tubes. In the gravid female, the eggs are contained in the large middle section of the inner gill (*i*), leaving free less than one-fourth of the gill at the anterior and at the posterior extremity, and also leaving free a narrow zone along the margin. This marsupial part has the interlaminar connections strongly developed, in the shape of interrupted septa, forming incomplete, intercommunicating water-tubes, filled by the eggs in a dense mass, not separated into placentæ. Since no sterile females are at hand, the exact arrangement of the interlaminar connections in a face view could not be made out. The charged marsupium is somewhat swollen and distended, so that the interlaminar connections have stretched out. The outer gill of the female has the structure of the gills of the male.

### 2. Group of *Diplodon granosus*.

Shell subovate or subtrapezoidal, rather elongated, not distinctly pointed behind, straight, not distinctly higher in the posterior part, nor oblique. Beak-sculpture well developed, but fine, and characteristically cut up into numerous fine nodules or granulations, thus obscuring the radial arrangement. The granular sculpture often continued a good distance upon the disk.

The essential character of this group is in the beak-sculpture, which, however, is very variable, although the granular structure is always more or less evident. It is hardly possible to give any additional characters, except that the hinge-teeth are moderately developed, subcompressed, and hardly ever stumpy. Two pseudocardinals are in each valve, but sometimes there are reductions.

I have very little material representing this group. The soft parts of only two specimens are at hand, one too young to be of any value, the other a male. Thus nothing can be said about the structure of the female. All my specimens seem to belong to one species, which is very variable, and has a very limited range in the coastal streams of eastern Brazil.

The genetic connections of this group likewise cannot be properly ascertained. The beak-sculpture does not seem to be very primitive, when compared with the other species of the genus. In the shape of the shell and the hinge, there is similarity to the next group (*chilensis*), which possibly may be the most primitive of the genus.

### 5. Diplodon granosus (Bruguière) (1792).

Compare: *Unio multistriatus* Lea, Von Ihering, 1890, p. 165.
*Unio psammactinus* Bronn, Von Ihering, 1893, p. 107.
*Diplodon expansus* Von Ihering, 1910, p. 134.
*Diplodon granosus* (Brugière), Simpson, 1914, p. 1250.

I am inclined to accept the earlier opinion of Von Ihering (1890), and that of Simpson, that a number of so-called "species," of which Simpson has given a full synonymy, belong here. Possibly several others should be included.

*Type-locality.*—Brazil and Guiana.

*Additional Localities.*—Rio de Janeiro (*psammactinus*, Philippi) (Von Ihering); coastal streams in eastern Brazil, between Rio de Janeiro and Bahia, but not to the south of Rio (Von Ihering); Rio Negro, Prov. Rio de Janeiro, Distr. St. Rita (Dunker's *coriaceus*, Von Ihering); Tayuara, Distr. Canta Gallo, Prov. Rio de Janeiro (Von Ihering); Rio Parahyba do Sul, Rio de Janeiro (Von Ihering); Nova Friburgo, Rio de Janeiro (Von Ihering). Rio Paraguassú, Bahia (Von Ihering, 1910, p. 139, as *multistriatus* Lea). Rio Doce, Espirito Santo (Von Ihering, 1910, p. 134, as *expansus* Kuester).

*New Localities.*—Mountain creek, Raiz da Serra, near Santos, São Paulo, Brazil (J. D. Haseman coll., July 26. 1908). One specimen with soft parts, male. Rio Ribeira, Iporanga, São Paulo, Brazil (J. D. Haseman coll., December 1. 1908). Two specimens, young, one with soft parts of the male type.

In addition, the Carnegie Museum possesses two specimens labeled "*ellipticus*, Brazil," from the Holland Collection, and one specimen labeled "*multistriatus*, Brazil," from the Juny Collection.

*Distribution.*—The new localities represented in the collection made by Haseman extend the range southward (southwestward) along the coast of Brazil beyond Rio de Janeiro into the southern portion of the state of São Paulo in the small coastal streams. The established range thus reaches from the Rio Paraguassú in the North to the Rio Ribeira in the South.

*Remarks.*—My material is entirely insufficient for the study of the various forms regarded as belonging here. Originally Von Ihering was inclined to unite all these forms with granular beak-sculpture into one species; but later he divided them according to the character of the beak-sculpture, although he admits that there is great variation in this respect. Simpson unites them again, at least in part, but he lets *granuliferus* Dunker stand, and even adds a new species, *D. semigranosus*.[13]

My specimens also vary in the development of the beak-sculpture and in the shape of the shell, but they might very well be forms of one and the same species. The two soft parts at hand are those of males, and the structure of the female is unknown.

The two young specimens from Iporanga show the granular beak-sculpture very well, and I should call them *D. granosus* by all means. Simpson (1914, p. 1249) has described from the same river-system (Rio Ribeira) at Iguapé, São Paulo, Brazil (near the mouth), a *D. mimus*, and Marshall (1917, p. 383, pl. 51, figs. 3–6) has redescribed and figured it. It is founded upon two specimens, larger than mine, and differing somewhat from each other in their proportions, and also from my specimens, but the differences may be individual. The measurements are:

| | Length. | Height. | Diameter. |
|---|---|---|---|
| Simpson | 37 mm. | 28 mm. = 76 pr. ct. of L. | 17 mm. = 46 pr. ct. of L. |
| Marshall | 45 " | 27 " = 60 " | 15 " = 33 " |
| My specimen | 29 " | 17.5 " = 60 " | 8.5 " = 29 " |
| Do. | 18 " | 11.5 " = 64 " | 5 " = 28 " |

My specimens agree very well with the figures and description, except that there is no lurid-purple in the nacre, which is dull (lurid) whitish.

[13] Habitats: "São Paulo River" (location unknown); "Ponte Grande" (location unknown); "Os Perus," São Paulo, Brazil. Marshall (1917, p. 387) redescribes and figures this species, and gives as type-locality: Rio Tieté, São Paulo, and the additional localities "Ponte Grande, São Paulo; Os Perus; and Ponta Grossa, Paraná." The location of Ponte Grande is still unknown. Ponta Grossa is on the headwaters of the Rio Tibagy, tributary to the Paraná Panema.

The beak-sculpture of Simpson's species is unknown, being entirely eroded. It may be that my specimens are this, but I hesitate to unite *D. mimus* with *granosus*, before the beak-sculpture of the former has been described.

### 3. Group of *Diplodon chilensis*.

Shell rather compressed, flattened upon the sides, subelliptical, subovate, subtrapezoidal, more or less elongate, not distinctly pointed behind, straight, and not distinctly higher in the posterior part, nor oblique. Beak-sculpture simple, with narrow, straight, uninterrupted radial bars, restricted to the region of the beaks, and not extending far upon the disk. Two of the median bars may be joined at their lower ends.

The generally subtrapezoidal shape of the shell, with flat sides, and the simple character of the beak-sculpture are the chief characters of the group, which may represent the most primitive type within the genus. The posterior end of the shell is mostly not pointed, but more or less rounded, and the posterior ridge is rather indistinct, not prominently angular.

A great number of "species" belong here, which are extremely hard to distinguish. It is in this group that I encountered the greatest difficulties in the identification of the species, and even at present I am not satisfied with the results. This is the more to be regretted, since I have abundant material with soft parts of some of these forms and have found that there are differences in the anatomy, which to all appearance are of specific value.

After many attempts to group these forms, I have finally concluded that the best way, the one that is least liable to lead into error, is to treat these forms *geographically*. It is not very likely that the same identical species occurs in widely separated river-systems.

Forms of this type are found over nearly the whole continent, but apparently they are rare or missing in the region of the great depression which runs from the La Plata up the Paraguay to the Amazon-drainage. I shall begin with the forms from Chile and Patagonia, and proceed then in the direction toward Brazil, going from South to North.

#### 1. Species from Chile and Patagonia.

I have very insufficient material of this group, and cannot express any positive opinion about the species. But it seems that all, or nearly all, of the forms known from Chile belong here. Simpson (1914, p. 1257) admits ten of them: *chilensis* Gray, *solidulus* Philippi, *gassiesi* Kuester, *aplatus* Reeve, *molinæ* Philippi, *modestus*

Kuester, *atratus* Sowerby, *obtusus* D'Orbigny, *chiloënsis* Kuester, *aureus* Simpson. But the differential characters of these are very obscure, and I should not be astonished if some of these names should prove to be synonyms.

Similar forms are known from the eastern foot of the Cordilleras in Patagonia, in the drainage of the Rio Negro. Of these the following material is at hand:

### 6. Diplodon patagonicus (D'Orbigny) (1835).

*Unio patagonicus* D'Orbigny, 1843, p. 610, Pl. 70, figs. 1–4.

*Diplodon patagonicus* Simpson, 1900, p. 885; 1914, p. 1275; Pilsbry, 1911, p. 610.[14]

*Type-locality.*—Rio Negro, 10–12 miles above its mouth.

*New Locality.*—Rio Limay, Patagonia (Received in exchange from W. Israël), one right valve.

*Distribution.*—Rio Negro and its tributary Rio Limay in Patagonia.

The specimen at hand is very poor, with the epidermis worn off, but it is undoubtedly this species, which is characterized by its elongated outline and a shallow radial groove upon the posterior slope.

This species is not at all related to *D. parallelopipedon* (Lea), with which it has been associated by Simpson. It has, indeed, a similar elongated outline, but the characteristic strong and elevated posterior ridge of the latter species is entirely absent.

### 7. Diplodon frenzeli (Von Ihering) (1893).

*Unio frenzelii* Von Ihering, 1893, p. 111, Pl. 4, fig. 12.

*Diplodon huapensis* Bartsch, 1906, p. 394, Pl. 27, fig. 1; Pl. 28, fig. 1; Pl. 29, fig. 2.

*Diplodon frenzeli* and *huapensis*, Simpson, 1914, pp. 1264, 1265.

*Type-locality.*—Patagonia.

*Other Localities.*—Patagonia, foot of the Cordilleras (Von Ihering); small lake on Victoria Island in Lake Nahuel Huapi, Argentina (Bartsch, *huapensis*).

*Locality Represented in Carnegie Museum.*—Lake Nahuel Huapi, Argentina (C. H. Eigenmann coll., 1919). One gravid female with soft parts.

*Distribution.*—Known from Patagonia, at the foot of the Cordilleras in the region of Lake Nahuel Huapi (Rio Negro drainage). The locality "Chile" given by Von Ihering is rather vague; and "Os Perus, São Paulo, Brazil," given by Simpson for *frenzeli* is probably incorrect.

My material is too poor to give a full account of this species, but I am sure that my only specimen belongs here, and I also believe that *huapensis* is the same.

[14] *Unio patagonicus* Reeve, XVI, 1865, Pl. 21, fig. 93, is not this.

This species has the indifferent and uncharacteristic outline of the forms of the *chilensis*-group: subelliptical or subtrapezoidal, with upper and lower margins subparallel, and rather elongated and compressed shell. It is, however, *remarkable for the anterior location of the beaks* (18 or 19 pr. ct. of the length). There is no radial furrow or groove on the posterior slope.

The color of the epidermis of my specimen (the largest known) is dark brown, and the epidermis is wrinkled with concentric lamellæ, but it has been largely eroded. According to Von Ihering, the color is dark brown in the larger specimens, but dark olive in smaller ones, sometimes with lighter green in places. The color of *huapensis* is brown posteriorly, grading to wax-yellow anteriorly.

In all other respects, chiefly in the hinge-teeth, my specimen agrees with the description of *frenzeli*; only the posterior end of the shell is a little more broadly rounded, but not very different from the specimen figured by Von Ihering on plate 4, fig. 12*i*.

*D. huapensis* has been compared by Bartsch with *frenzeli*, and he says that it can readily be distinguished from it by the narrower outline, that means to say by the height being less in proportion. This, however, is not correct, as can be seen by comparing the measurements.

The only difference I can see in *huapensis* is the more tapering posterior end. But since this species is founded upon two specimens, of which only one has been figured, this might very well be an individual character.

In the following measurements I leave out Von Ihering's specimens from Chile, which appear to me a little doubtful.

MEASUREMENTS.

| | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|
| *Huapensis* (figure) | 53 mm. | 25.5 mm. =48 pr. ct. of L. | 14 mm. =26 pr. ct. of L. | at 10 mm. =19 pr. ct. of L. |
| Do. (type, text) | 55 " | 25.9 " =47 " | 14.5 " =26 " | |
| Do. (text) | 57 " | 27.3 " =48 " | 16 " =28 " | |
| *Frenzeli* 5*b* Von Ihering | 56 " | 26 " =46 " | 16 " =29 " | 10 " =18 " |
| Do. 5*a* Von Ihering | 58 " | 28 " =48 " | 17 " =29 " | 11 " =19 " |
| Do. Von Ihering | 68 " | 34 " =50 " | 20 " =29 " | =18 " |
| My specimen (♀) | 71 " | 36.5 " =51 " | 16 " =23 " | 13 " =18 " |

Thus my specimen is more compressed than any of the others; however, a variation of the diameter from 23 to 29 pr. ct. is not at all unusual.

*Anatomy.*—The specimen at hand has been preserved with the soft parts, and proved to be a gravid female with glochidia.

Color of soft parts whitish, with black pigment near anal and branchial openings extending forward a good distance along the margin of the mantle, and becoming brown.

Bartsch has given a description of the soft parts of *huapensis*, which refers chiefly to the general features, the color, the structure of the siphons, and the shape of the gills and palpi. But no particulars as to the structure of the gills are given.

Anal opening slit-like, closed above, closed part about four times as long as the open, the latter with the inner edge smooth, and separated from the branchial by a solid mantle-connection. Branchial opening with distinct papillæ. Palpi of moderate size, subtriangular, lower margins curved, posterior margins not connected at base.

Gills nearly of the same width posteriorly, the inner much wider than the outer anteriorly. Outer gill subtriangular, its anterior end at the highest point of the mantle-attachment-line. Inner gill with gently convex margin, very little narrower anteriorly, broadly attached in front, its anterior end immediately behind the palpi. Inner lamina of inner gill entirely connected with abdominal sac. Interlaminar connections of non-marsupial gills weakly developed, scattered. *Marsupium* located in the inner gill, but not occupying all of it, leaving nearly one-fifth of the gill free anteriorly, and about two-fifths posteriorly, so that the marsupium is distinctly shifted forward, lying in the second and third fifth of the gill (from the anterior end). Interlaminar connections of the marsupium forming interrupted septa, the septiform structure apparently prevailing (this is not quite clear, since the structure is obscured by the masses of glochidia). The charged marsupium is a little swollen, and the glochidia fill it in a loose mass, not being conglutinated.

*Glochidium* subtriangular, strongly oblique, with the point of the lower margin located vertically below the posterior end of the hinge-line. Hooks are present and of the normal S-shape. L. 0.25, H. 0.20; L. of hooks: 0.05 mm. Compared with other species, the glochidium is rather small.

### 2. Species from coastal streams of southern Brazil.

It is a noteworthy fact that species of the *chilensis*-type seem to be absent from the system of the Rio de la Plata (with the exception of the drainage of the upper Paraná). They also seem to be absent in the great Amazons-basin, and northward. But they are found rather plentifully on the Brazilian plateau, beginning at its southern extremity, in the coastal streams in Rio Grande do Sul, going thence northward, and crossing over in São Paulo and Paraná into the drainage of the upper Paraná River.

We shall take up first the species of the coastal streams, and I wish to call

attention (as has been done by Simpson in the case of *D. mimus*) to the great resemblance of these shells, not only among themselves, but also to the North American *Elliptio complanatus* (Dillwyn), distributed over the Atlantic streams of the eastern coast of the United States from Georgia to Maine. This resemblance, of course, is only external and superficial. Closer examination of the hinge, of the adductor-scars, and, if visible, of the beak-sculpture, at once reveals important differences. The anatomy is entirely different.

### 8. Diplodon imitator Ortmann, sp. nov.

*Shells:* Pl. XXXIV, figs. 5, 6, 7; Pl. XXXV, figs. 1, 2. *Anatomy of gills:* Pl. XLV, fig. 1. *Section of gills:* Pl. XLVII, fig. 6. *Glochidium:* text-fig. 4*b* (p. 469).

*Type-locality.*—Rio Vaccahy-mirim, Santa Maria, Rio Grande do Sul, Brazil (J. D. Haseman coll., January 29. 1909). Twenty-three specimens, all with soft parts, among them males, barren and gravid females, with eggs and with glochidia. Type-set: Carn. Mus. Cat. No. 61.9248. (This is in the drainage of the Rio Guahyba-Jacuhy, far up in the headwaters).

*Additional Locality.*—Rio Jacuhy, Cachoeira, Rio Grande do Sul, Brazil (J. D. Haseman coll., January 26. 1909). One barren and one gravid female, with eggs, both young. (This is farther down, in the middle part of the Rio Jacuhy.)

(Originally there were thirty-four specimens from the type-locality at my disposal, all with soft parts.)

Only once before has a form of this group been reported from the Guahyba-drainage, viz. *D. martensi* Von Ihering, from Taquary and Santa Cruz (probably from tributaries of the lower Jacuhy (See Von Ihering, 1893, p. 102). But these are not typical *martensi*, the original of the latter being "probably from São Paulo)."[15] The dimensions of these specimens from Rio Grande do Sul given by Von Ihering agree fairly well with those of the real *U. martensi*, chiefly the relation of height to length: 49 pr. ct. in two specimens from Rio Grande do Sul, 49 pr. ct. (text) or 53 pr. ct. (figure) in *martensi*. But these dimensions do not agree with my specimens, where the height ranges from 55 to 64 pr. ct. and never falls as low as in *martensi*. The diameter of *martensi* is also greater than in my material. For this reason I am compelled to describe my shells as a new species.

*Description of Shell.*—Of medium size (maximum length 80 mm.), moderately solid, rather thin when young, compressed (diameter 26 to 33 pr. ct. of length), subelliptical, subovate, or subtrapezoidal, moderately elongated (height 55 to

[15] It is much to be regretted that the type-locality is not better known. It is very doubtful, on account of the great similarity of these forms, whether the real *martensi* can ever be positively identified.

64 pr. ct. of length). Valves not gaping. Dorsal margin nearly straight or very gently convex, passing gradually into the anterior margin (rarely forming an indistinct angle). Posterior upper margin forming a blunt angle with the posterior margin or passing gradually into it. Posterior margin obliquely descending, more or less curved, and curving more strongly into the lower margin, without forming a distinct posterior angle. The lower posterior end of the shell is rounded, but hardly biangular. Lower margin in young specimens gently convex, in older ones it is rather straight in the middle. Anterior end of shell not, or very little, narrower than the posterior end. The shell is thus rather straight and not oblique.

Valves only slightly convex, rather flattened upon the sides, with the posterior ridge very indistinct and broadly rounded. Posterior slope somewhat compressed. Greatest diameter near the middle of the shell, but not posterior to it. Beaks not swollen, and not elevated, located at from 20 to 28 pr. ct. of the length. Beak-sculpture consisting of about fourteen to sixteen rather sharp and fine, short, radial bars, 5 to 7 mm. long, those upon the posterior ridge hardly longer than the rest, and none of them uniting in the middle of the shell with their lower ends. No distinct granulations present, but sometimes there are a few irregular oblique wrinkles upon the posterior slope near the beaks. A short, narrow lunula in older shells.

Epidermis in young specimens rather smooth and shining, but with fine, irregular, concentric striæ, nowhere lamellar. In old specimens it is less smooth, chiefly on the posterior slope and toward the lower margin with more crowded and rougher striæ. Crinkled radial lines hardly indicated upon the shell. Color in young specimens greenish bronze or brownish, sometimes with indistinct brownish concentric bands, in older shells greenish tints disappear, and the epidermis is dull brown or blackish brown.

Hinge-line gently curved. Ligamental sinus over the middle of the lateral tooth or slightly behind it, in older shells over its last third. Laterals curved, one in right, two in left valve, somewhat rough posteriorly. Pseudocardinals normally two in each valve. In young specimens those of the right valve are obliquely and forwardly descending, compressed, the anterior low and narrow, the posterior higher and a little thicker, crenulated. In older specimens the posterior is thicker and becomes generally more triangular and stumpy. Those of the left valve of young specimens are also compressed, but subtriangular and not very long, crenulated, the anterior one larger than the posterior. In old shells these two teeth are more stumpy, triangular, and not compressed. In rare cases reductions take place, chiefly with regard to the anterior tooth of the right valve, or with regard to the

posterior in the left valve, which may become very small, and sometimes an accessory third posterior tooth may develop in the right valve. Thus the pseudocardinals are quite variable in number, shape, size, compression, and development of rugosities.

Cavities of shell and beaks shallow. Nacre blueish white or white, often discolored and with lurid tints (grayish purple) toward the beak-cavities, iridescent posteriorly.

Anterior adductor-scar distinct and impressed, subtriangular. Anterior retractor-scar separated from it, small, round, deeply impressed. Anterior protractor-scar connected with adductor-scar, forming a posterior process of it. Posterior adductor-scar shallow, subtriangular, with an upper process formed by the posterior retractor-scar. Pallial line distinct. Dorsal muscle scars a few, lying in a line in the beak-cavity.

MEASUREMENTS.

| No. | Sex. | Length. | Height | Diameter. | Beaks. | Figure. |
|---|---|---|---|---|---|---|
| 11... | ♂ | 40.5 mm. | 24 mm. =59 pr. ct. of L. | 12 mm. =30 pr. ct. of L. | at 11 mm. =27 pr. ct. of L. | |
| 16... | ♂ | 43 " | 27 " =63 " | 11 " =26 " | 11 " =26 " | |
| 21... | ♀ | 47 " | 30 " =64 " | 15 " =32 " | 11 " =23 " | Pl. XXXV, fig. 2. |
| 29... | ♂ | 62 " | 34 " =55 " | 20.5 " =33 " | 14 " =23 " | Pl. XXXIV, fig. 5. |
| 32... | ♀ | 76 " | 44.5 " =59 " | 23.5 " =31 " | 16.5 " =22 " | Pl. XXXIV, fig. 7. |
| 33... | ♀ | 80 " | 44 " =55 " | 26.5 " =33 " | 16 " =20 " | Pl. XXXV, fig. 1. |

*Anatomy.*—Anal opening slit-like, shorter than branchial opening, closed above; closed part about twice as long as open part, no supra-anal formed. Branchial opening separated from anal by a solid connection of the inner mantle-edges. Inner edge of anal almost smooth, that of branchial with distinct papillæ. In front of the branchial the mantle-edges are unconnected. Palpi subtriangular, a little longer than wide, their posterior margins connected at base.

Gills long, the outer subtriangular, wider in the middle than the inner. The inner not triangular, wider than the outer anteriorly, its anterior end attached to the space between anterior end of outer gill and palpi, and in contact with the posterior base of the latter. Inner lamina of inner gill entirely connected with abdominal sac.

Non-marsupial gills (Pl. XLV, fig. 1*a*) with few, scattered, irregularly disposed interlaminar connections. Marsupium (Pl. XLV, fig. 1*b*) located in the inner gills, occupying only a part of them, at and in front of the middle; at anterior end about one-fifth of the gill remains non-marsupial, and at the posterior end about two-fifths, so that the marsupium occupies two-fifths of the gill, the second and third from the anterior end. This location of the marsupium is constant for

the species (observed in seventeen females), with the only qualification that in young females the marsupium is smaller (less than two-fifths of the gill) but has a similar position.

Marsupial part formed by interrupted septa (Pl. XLV, fig. 1*b*; Pl. XLVII, fig. 6). The arrangement into septa is distinct, but they are frequently interrupted, and their solid portions are short. In the middle of the marsupium they are at the utmost six to eight times as long as thick, and in its other parts they are very short. A distinct quincuncial (reticulate) arrangement is not seen. Toward the margin of the gill the septiform arrangement is again more distinct.

The embryos fill the marsupium in an irregular mass, and the charged marsupium is moderately swollen. Placentæ are not formed.

*Glochidium* (text-fig. 4*b*, p. 469, observed in six specimens) subtriangular, slightly oblique, anterior and posterior margins convex, converging to a point, anterior margin longer than the posterior. Hooks present, of the Hyriine type, with the S-shaped curve. L. 0.27 to 0.28 mm.; H. 0.27 to 0.28 mm.; L. of hook: 0.09 mm.

It should be remarked that in one female the glochidia were immature, and no hooks could be seen; three females had only eggs, and one female was in the act of discharging. The dates of collecting, Jan. 26 and 29, should be recorded as showing the breeding season (midsummer of Southern Hemisphere).

*Remarks on the Specific Characters.*—As will be seen from the descriptions of the following species, *D. simillimus*, *D. vicarius*, and *D. decipiens* are very closely allied to the present species in the shape of the shell; *vicarius* can be readily distinguished by the biangular posterior ridge, and *D. simillimus* is a smaller shell. In other respects it is almost impossible to distinguish these species by the *shell alone*. The few obscure, differentiating characters will be pointed out below under the respective species. However, the investigation of the soft parts has shown that there are interesting differences chiefly in the *location of the marsupium*. In the present species, the marsupium is most fully developed, occupying a rather large part of the inner gills, slightly gravitating toward the anterior end. In the following species (chiefly *simillimus* and *vicarius*) it will be seen that this tendency is increased, and the marsupium becomes smaller, and is being shifted more distinctly forwards (Compare pl. XLV, fig. 1*b*, with Pl. XLV, figs. 2*b*, and 3). It will also be seen that there are slight differences in the glochidia with regard to obliquity and size.

9. Diplodon simillimus Ortmann, sp. nov.

*Shells:* Pl. XXXV, figs. 3, 4, 5, 6. *Anatomy of gills:* Pl. XLV, fig. 2.
*Glochidium:* Text-fig. 4*c*, p. 469.

*Type-locality.*—Rio Nhundiaquara, Morretes, Paraná, Brazil (J. D. Haseman coll., January 3, 1909). *Type-set:* Carn. Mus. Cat., No. 61.9250. Thirty-two specimens with soft parts, males, barren and gravid females with glochidia.

About a dozen additional specimens belonging to the same original lot have been studied. The locality is in a small coastal stream emptying into the Bay of Paranagua.

No shells have ever been reported from the region of Paranagua Bay in Paraná. However, from a little less than one hundred miles to the south, in Santa Catharina, near Barra Itapocu (I believe that the Rio Itapoca, as given by Marshall, stands for this), *Diplodon santamariæ* Simpson has been described (Simpson, 1914, p. 1270; and Marshall, 1917, p. 386, Pl. 52, fig. 6; Pl. 55, figs 1–4). This is founded upon three specimens only, and resembles our species to a degree. But judging from description and figures, it is somewhat larger (max. 63 mm.), longer (H. 52–59 pr. ct. of L.), and the hinge has the posterior tooth of the left valve missing. Since nothing is known of the anatomy of *D. santamariæ*, and the locality is not the same, it would be rash to unite our specimens with this species.

Our species also is much like *U. martensi* Von Ihering, and might fall under this according to Von Ihering's conception. But it cannot be united with it on account of the different dimensions. While in *martensi* the height is said to be from 49 to 57 pr. ct., our specimens are mostly less elongated, with the height from 53 to 66 pr. ct. of the length. In *D. martensi* the diameter is 32 to 35 pr. ct., in the present species from 26 to 37 pr. ct. (this agreeing better with *martensi* than with *imitator*). But in the absence of exact localities for *martensi* and any knowledge of its anatomy, and in view of the general resemblance of all of these shells, it is impossible to identify our shell with any previously described, and no other alternative exists, except to describe it as new.

In the characters of the shell *D. simillimus* is very close to *D. imitator*. The description of the latter species would fit it very well, and I shall here only emphasize the distinguishing characters.

1. *D. simillimus* is a smaller shell (max. length 61 mm., as against 80 mm. in *imitator*).

2. The trapezoidal shape, with an angle between the upper and the posterior margins, is seen here only in very young shells. In older shells these two margins form a rather regular curve.

3. The lower margin of the shell of *D. simillimus* is frequently more nearly straight, so that the shell of older specimens appears more humped.

4. Color of epidermis with hardly any green tints, but light to dark bronze-brown, in old shells brown-black.

5. Pseudocardinal teeth never stumpy, chiefly in left valve, but always compressed, although the two of the left valve and the posterior in the right are rather thick in old specimens.

MEASUREMENTS.

| No. | Sex. | Length. | Height. | Diameter. | Beaks. | Figured. |
|---|---|---|---|---|---|---|
| 5... | ♂ | 36.5 mm. | 21.5 mm. =59 pr. ct. of L. | 9.5 mm. =26 pr. ct. of L. | at 8.5 mm. =23 pr. ct. of L. | |
| 29... | ♂ | 37.5 " | 23 " =61 " | 11 " =29 " | 10 " =27 " | |
| 18... | ♀ | 42.5 " | 22.5 " =53 " | 11 " =26 " | 9.5 " =22 " | |
| 11... | ♂ | 45 " | 27 " =60 " | 13 " =29 " | 9 " =20 " | Pl. XXXV, fig. 3. |
| 23... | ♀ | 59 " | 39 " =66 " | 22 " =37 " | 14 " =24 " | |
| 22... | ♀ | 61 " | 37 " =61 " | 20.5 " =34 " | 15 " =25 " | Pl. XXXV, fig. 5. |

The characters of the shells of this species are rather poorly marked, and can be ascertained only by the examination of extensive material. I have discovered, however, that there are important and constant differences in the anatomy.

*Anatomy.*—Fully agreeing with that of *D. imitator*, but the marsupium is different (See Pl. XLV, fig. 2). It is located in the anterior part of the inner gill, entirely anterior to its middle, and extending forward to within a short distance of the anterior end of the gill, so that anteriorly less than one-tenth of the gill is non-marsupial, while posteriorly fully the posterior half of it is non-marsupial. The interlaminar connections form interrupted septa, but the septiform structure is less distinct than in *D. imitator*, and more of a reticulated (or irregular quincuncial) arrangement is evident. This structure of the marsupium is the same in all females investigated (altogether twenty individuals), and only in young ones is the marsupial part smaller.

The *Glochidium* (Text-fig. 4*c*, p. 469) differs from that of *D. imitator* in being more distinctly oblique, and being longer than high. L. 0.28 mm., H. 0.24 mm. There are hooks of the same type, which are about 0.10 mm. long.

My specimens were collected on January 3, which date indicates the breeding season, probably its middle, for eight females had only eggs, while nine had glochidia, in part not mature, and with the hooks yet unformed.

The remarkable fact brought out by the study of the anatomy is that, *while the species is extremely hard to distinguish from imitator by the shell, it has at least two anatomical characters (marsupium and glochidium), which are very well marked and constant.*

10. Diplodon vicarius Ortmann, sp. nov.

*Shells:* Pl. XXXV, figs. 7, 8; Pl. XXXVI, figs. 1, 2. *Anatomy of gills:* Pl. XLV, fig. 3. *Glochidium:* Text-fig. 4*d*, p. 469.

*Type-locality.*—In creeks, Aqua Quente (eight miles from Iporanga), São Paulo, Brazil, tributaries of Rio Ribeira (J. D. Haseman coll., November 27, 1908). *Type-set:* Carn. Mus., Cat. No. 61.9251; fifteen specimens all with soft parts, males, barren and gravid females.

*Additional Locality.*—Rio Ribeira, Iporanga, São Paulo, Brazil (J. D. Haseman coll., December 1. 1908). One specimen, male, with soft parts.

Only one species of *Diplodon* has been described from the Rio Ribeira; this is *D. mimus* Simpson (1914, p. 1249; Marshall, 1917, p. 383, Pl. 51, fig. 3) from Iguapé, São Paulo, at the mouth of the river. As has been pointed out above (p. 486), this species might possibly be *D. granosus.* But on the other hand a few particulars agree with the present species, as, for instance, the biangulation of the posterior end and the general resemblance to *Elliptio complanatus* mentioned by Simpson. Yet our shells cannot be this, because they are larger, less convex, and have different dimensions. *D. mimus* is smaller (max. 45 mm.), and has, according to the measurements given, a considerably higher (60 to 76 pr. ct.) and more swollen (D. 33 to 46 pr. ct.) shell, while *D. vicarius* has the height only from 52 to 63 pr. ct. and the diameter from 26 to 31 pr. ct., and is a good deal larger (L. 53 to 68 mm.). Of course, our form may fall under *martensi* Von Ihering, but for the same reasons as in the case of the two preceding species, it cannot be called by this name, and thus we must describe it as new.

It may perhaps be that *D. vicarius*, of which we do not know the beak-sculpture, is the older stage of the young specimens recorded from Iporanga as *D. granosus* (See p. 485). The shape and dimensions agree fairly well, but the size is very different, the maximum length of *granosus* being only 29 mm. and no intermediate specimens between these and minimum length of *vicarius* (53 mm.) are at hand. Thus the question must remain unsettled. *D. granosus* from other localities is also always much smaller than *vicarius.*

This species is also extremely similar to *D. imitator* and *D. simillimus.* In size it stands between them (max. length 68 mm.). The outline is also subtrapezoidal or subelliptical, and the shell is quite compressed, resembling the shape of *Elliptio complanatus* of the United States. The lower margin in the shells before me is always rather straight, but I have not very young specimens. However, from the growth-lines it is seen that young shells must have had a gently curved lower margin. In none of my specimens is the beak-sculpture preserved.

*Characters of the Shell.*—The description of *D. imitator* might also serve for this species. However, the following differences are noticeable:

1. Posterior ridge of shell broad, and more or less distinctly biangulate, producing a biangulation also of the posterior end of the shell. This is the most striking character of the shell. In both *D. imitator* and *simillimus* the posterior end of the shell is evenly rounded without any trace of angulations.

2. Epidermis not so shining as in the two other species, which is due to the development of additional fine concentric wrinkles, which are irregular and best developed upon the posterior slope and near the lower margin. Upon the disk they form indistinct radiating lines (or narrow bands), which are obsolete in the two other species. Color of epidermis of *vicarius* lighter or darker brown, without green tints, and without bronzy lustre.

The hinge-teeth are generally of the type of *D. simillimus*, *i.e.*, they do not become stumpy in old shells. They are, however, very variable, and much cut up, more so than in the two other species, and the posterior pseudocardinal of the left valve frequently is quite small or rudimentary. The nacre is whitish, but often inclines to lurid tints (purplish gray).

MEASUREMENTS.

| No. | Sex. | Length. | Height. | Diameter. | Beaks. | Figured. |
|---|---|---|---|---|---|---|
| 13... | ♂ | 53 mm. | 31 mm. =58 pr. ct. of L. | 15.5 mm. =29 pr. ct. of L. | at 12 mm. =23 pr. ct. of L. | Pl. XXXV, fig. 7. |
| 9... | ♀ | 53.5 " | 33.5 " =63 " | 14 " =26 " | 12 " =22 " | Pl. XXXVI, fig. 2. |
| 10... | ♀ | 57 " | 34.5 " =61 " | 16 " =28 " | 11.5 " =20 " | |
| 1... | ♀ | 58.5 " | 33.5 " =57 " | 15 " =25 " | 15 " =26 " | |
| 6... | ♂ | 67 " | 35 " =52 " | 19 " =28 " | 16 " =24 " | |
| 15... | ♀ | 68 " | 40 " =59 " | 21 " =31 " | 15 " =22 " | Pl. XXXV, fig. 8. Pl. XXXVI, fig. 1. |

No sexual differences in the shell.

*Anatomy.*—I have eight females, six of which are gravid; three with eggs, three with glochidia (immature in one). The structure of the soft parts is exactly as in the preceding species, except that of the marsupium (Plate XLV, fig. 3). As in *D. simillimus*, the marsupium is located in the anterior portion of the inner gill, anterior to the middle, but it occupies a still smaller part, and does not extend so near to the anterior end, and does not reach the middle of the gill. Anteriorly about one-ninth of the gill is non-marsupial, and posteriorly over half of it. The interlaminar connections are arranged in interrupted septa, the septiform arrangement being most evident anteriorly and in the middle of the marsupium, while posteriorly the arrangement is reticulate (indistinctly quincuncial).

The *glochidium* (Text-fig. 4*d*, p. 469) is similar to that of *D. simillimus*, oblique, but slightly longer. L. 0.30, H. 0.24 mm. There are hooks of the same type, which

are at least 0.09 mm. long. In one specimen with immature glochidia no hooks could be seen.

In this case also the breeding season falls in the winter months of the northern hemisphere, but apparently a little earlier than in the other species (end of November).

Thus this species has anatomical characters of its own, chiefly observable in the size and location of the marsupium. It agrees most closely with *D. simillimus.*

### 3. Species from the drainage of the upper Paraná.

I have material belonging to the *chilensis*-group from the following tributaries of the Paraná: Rio Iguassú, Rio Tieté, and Rio Grande in São Paulo. A form from the Iguassú is noticeably very closely related to the three species from the coastal streams just described. We should bear in mind that the head-waters of the Iguassú, from which this form comes, are in close proximity to those of the Rio Nhundiaquara and Rio Ribeira on the eastern watershed.

### 11. Diplodon decipiens Ortmann, sp. nov.

*Shells:* Pl. XXXVI, figs. 3, 4, 5, 6. *Anatomy of gills:* Pl. XLV, fig. 4. *Section of gills:* Pl. XLVII, fig. 7. *Glochidium:* Text-fig. 4*e*, p. 469.

*Type-locality.*—Creek, tributary to the Rio Iguassú, Serrinha, Paraná, Brazil (J. D. Haseman coll., December 23. 1908). *Type-set:* Carn. Mus. Cat. No. 61.9253, thirteen specimens, males, barren and gravid females, all with soft parts.

No *Naiades* have hitherto been known from the river-system of the Iguassú, and, as in the preceding species, none of the names of species which may occur here, can be applied to our specimens with any degree of certainty. Therefore we introduce this form as a new species.

In the *shape of the shell* this species is very close to the three preceding, especially *imitator* and *simillimus,* which it resembles in its subelliptical or subtrapezoidal outline. The latter shape is seen chiefly in younger specimens, while older ones become more subelliptical. The posterior ridge and the posterior end are never biangulate as in *vicarius.* In the glossy epidermis, *D. decipiens* also agrees better with *imitator* and *simillimus,* and the radial lines formed of fine wrinkles are poorly developed. The general description given for *imitator* might be repeated for this species, and the beak-sculpture in particular has the same character. Nevertheless the following peculiarities should be mentioned as diagnostic:

1. The beak-sculpture has a smaller number (ten to twelve) of radial bars, the bars having the same length (5 to 7 mm.)

2. The outline of the shell is more frequently subelliptical, often rather regularly so, with both upper and lower margins almost equally curved. In some specimens, indeed, the lower margin is more nearly straight, but this never causes a distinctly humped shape (so often seen in *simillimus*). No trace of biangulation posteriorly.

3. Epidermis in young shells bronzy-brown or bronzy-green; in older ones it becoming a deep chestnut-color, inclining partly to blackish.

In size this species stands between *imitator* and *vicarius* (maximum length 73 mm.). The relative dimensions are very much like those of the other three species. The hinge-teeth most resemble those of *simillimus*, never being stumpy, as in *imitator*; they are not much cut up; and the posterior pseudocardinal in the left valve has a strong tendency to disappear, being sometimes entirely missing. The nacre is whitish, but generally lurid (purplish gray) in the cavity.

### Measurements.

| No. | Sex. | Length. | Height. | Diameter. | Beaks. | Figured. |
|---|---|---|---|---|---|---|
| *a*... | ♂ | 26 mm. | 14.5 mm. =56 pr. ct. of L. | 6 mm. =23 pr. ct. of L. | at 6.5 mm. =25 pr. ct. of L. | |
| *c*... | ♀ | 35 " | 20.5 " =59 " | 9.5 " =27 " | 7.5 " =21 " | Pl. XXXVI, fig. 6. |
| 3... | ♀ | 58 " | 32.5 " =56 " | 18.5 " =32 " | 15 " =26 " | Pl. XXXVI, fig. 5. |
| 4... | ♂ | 67 " | 36.5 " =54 " | 20.5 " =31 " | 15 " =22 " | Pl. XXXV, fig. 3. |
| 10... | ♀ | 70 " | 38 " =54 " | 25 " =36 " | 16 " =23 " | |
| 6... | ♀ | 73 " | 40 " =55 " | 25 " =34 " | 16 " =22 " | Pl. XXXVI, fig. 4. |

No sexual differences in the shell.

*Anatomy.*—Aside from three very young specimens, which probably are a male and two females, I have six males of good size, and one barren female, a gravid female with eggs, and two females with glochidia (in one of them immature).

The anatomy is similar to that of *D. imitator*, *simillimus*, and *vicarius*, but the marsupium (Pl. XLV, fig. 4*b*) is quite different, essentially differing from that of the other species. It is located in the middle of the inner gill, leaving between one-fifth and one-fourth of the gill at the anterior end, and about one-third of it at the posterior end non-marsupial. Thus the marsupial portion is rather large, and more of it is anterior rather than posterior to the middle. This location comes nearer to what is seen in *D. imitator*, than in the other two species. The most striking character, however, which we have not before encountered, is that the interlaminar connections of the marsupial part are not interrupted, but form *continuous septa*, running from near the base of the gill close to the margin. These septa are heavy and stand very closely, forming regular, isolated water-tubes (See section on Pl. XLVII, fig. 7). The whole of the marsupium has this structure, and no inter-

rupted septa are seen anywhere. That these septa are only a modification of the scattered interlaminar connections is shown by the fact that the latter are found in the non-marsupial gills (See outer gill on Pl. XLV, fig. 4*b*, and gills of male, Pl. XLV, fig. 4*a*). All four of my large females show this arrangement, and in the two young ones traces of the beginning of this structure are seen. The embryos fill the water-tubes in loose masses, not forming distinct placentæ.

Glochidium (Text-fig. 4*e*, p. 469) much like that of *D. vicarius*, oblique, L. 0.31, D. 24 mm., with hooks, 0.09 to 0.11 mm. long. One specimen has immature glochidia, but rudimentary hooks can be seen. The date of collecting (December 23) gives a hint as to the breeding season.

While this species is very close to the three preceding in the characters of the shell, it has differences in the soft parts, which are very striking. The structure of the marsupium is extremely interesting, and there is no doubt that it must be regarded at least as of specific value, representing a high specialisation of this organ.

### 12. Diplodon paulista (Von Ihering) (1893).

*Anatomy of gills:* Pl. XLVI, fig. 1. *Section of gills:* Pl. XLVIII, fig. 1;
*Glochidium:* Text-fig. 4 f. p. 469.

*Unio paulista* Von Ihering, 1893, p. 93, Pl. 4, fig. 7.
*Diplodon paulista* Simpson, 1900, p. 873; 1914, p. 1229.

*Type-locality.*—Piracicaba, São Paulo, Brazil; according to Nehring (1893, p. 166) in Rio Piracicaba Mirim.

*New Localities.*—Rio Tieté, Mogy das Cruzes, São Paulo, Brazil (Headwaters of R. Tieté) (J. D. Haseman coll., July 19, 1908) males, barren and gravid females, originally twenty-five in the lot, all with soft parts. Rio Tieté, Sapina, São Paulo (Exact location unknown, but must be near city of São Paulo) (J. D. Haseman coll., July 23, 1908) one male with soft parts. Creek, tributary to Rio Mogy Guassú, Mogy Mirim, São Paulo, Brazil (tributary to Rio Grande and Paraná) (J. D. Haseman coll., August 7, 1908) males and gravid females, originally seventeen specimens in the lot, all with soft parts.

A detailed description of five specimens has been given by Von Ihering, but the specific characters have remained obscure. The specimens before me agree very well with this description, but it should be noted that the two forms of the shell supposed by Von Ihering to belong to the male and female, do not represent sexual differentiation, but simply individual variations. The more regularly ovate outline, believed to belong to the male, is in fact rather rarely well-developed,

while the other, somewhat more oblique, is more frequent; but both pass insensibly into each other. According to my material younger specimens are more apt to exhibit the more regularly ovate outline.

This species is not very closely allied to those mentioned on the preceding pages, but represents a somewhat different type, and inclines towards the *ellipticus*-group by its often slightly oblique shell. It is much smaller than *imitator, vicarius,* and *decipiens,* and also does not attain the size of *simillimus.* The largest specimen before Von Ihering was 57 mm. long, while my largest falls even short of this (45 mm. from Rio Tieté, 51 mm. from Mogy Mirim). The subtrapezoidal shape is only distinct in very young individuals; in larger specimens it becomes subelliptical or subovate, generally a little higher posteriorly and slightly oblique. The ground-color of the epidermis is greenish-olive, and never distinctly brownish, although old specimens may become blackish green. The beak-sculpture consists of fine, sharp, and short radial bars, the number of which is sixteen to eighteen, the median pair having a tendency to unite at the lower ends.

The characters of the inside of the shell have been well described by Von Ihering. The left valve has generally only one pseudocardinal, but sometimes there is a trace of a second posterior one. It should be noted that, as described by Von Ihering, the posterior retractor-scar is separated from, and stands above the posterior adductor-scar, but *not always,* as in some cases it is connected with it, and this may be different, even in the right and left valve of the same individual.

Measurements.

| No. | Sex. | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|---|
| Von Ihering..... | | 48 to 57mm. | 59 to 65 pr. ct. of L. | 31 to 35 pr. ct. of L. | 22 to 26 pr. ct. of L. |
| *Mogy das Cruzes* | | | | | |
| | ? | 15.5 mm. | 8.5 mm. =55 " | 4 mm. =26 " | at 4 mm. =26 " |
| 18....... | ♀ | 27 " | 16 " =59 " | 8 " =30 " | 6 " =22 " |
| 10....... | ♂ | 38 " | 22 " =58 " | 11.5 " =30 " | 7.5 " =20 " |
| 23....... | ♀ | 38 " | 24 " =63 " | 14 " =37 " | 10 " =26 " |
| 7....... | ♂ | 41 " | 27.5 " =67 " | 14 " =34 " | 10 " =24 " |
| 14....... | ♂ | 45 " | 27 " =60 " | 16 " =36 " | 11 " =24 " |
| *Mogy Mirim* | | | | | |
| 9....... | ♂ | 35 " | 22 " =63 " | 14.5 " =41 " | 10 " =29 " |
| 14....... | ♂ | 39 " | 23.5 " =60 " | 13 " =33 " | 9.5 " =24 " |
| 13....... | ♂ | 40.5 " | 24 " =58 " | 15 " =37 " | 11.5 " =28 " |
| 12....... | ♂ | 42 " | 28 " =67 " | 18 " =43 " | 11.5 " =27 " |
| 3....... | ♀ | 48.5 " | 29 " =60 " | 16.5 " =34 " | 13 " =27 " |
| 5....... | ♂ | 51 " | 32 " =63 " | 18 " =35 " | 13 " =26 " |

My two sets from the Rio Tieté and from a creek tributary to Rio Mogy Guassú, differ slightly from each other. In the former the size is a little smaller, and the young shells are rather more elongated, thus rendering the average height less. The diameter is also not so great in the shells from the Tieté. The measure-

ments of the dimensions of the two sets largely overlap, and they agree very well with those given by Von Ihering. Of course, my material being more plentiful, the range of the dimensions is wider.

An apparently allied form is *D. suppositus* Simpson (1914, p. 1245; Marshall, 1917, p. 385, Pl. 51, fig. 2; Pl. 54, fig. 1–4).[16] The type is, according to Marshall, from "Paraná, Brazil," and other specimens are from Rio Tieté, São Paulo, and other localities in southern Brazil. This is also a comparatively small form, but, according to the measurements given, it is more elongated, the height being in the type 52 pr. ct. of the length (53 pr. ct. according to Marshall), and in another specimen 58 pr. ct. This differs somewhat from our specimens (58 to 67 pr. ct.) and from Von Ihering's *paulista* (59 to 65 pr. ct). In addition *suppositus* has a chestnut-bronzy epidermis, while it is greenish in *paulista*. Thus the two forms do not agree.

*Anatomy.*—I have investigated the soft parts of all of my shells, and there were altogether, aside from several small ones, where the sex could not be ascertained, nineteen males, six barren females, five gravid females with eggs, and seven gravid females with glochidia.

The anatomy in general is like that of the genus *Diplodon*. But in this case again the marsupium (Pl. XLVI, fig. 1) in its size and location shows specific peculiarities, exhibited by *all* of my females. It agrees with the preceding species in the fact that it occupies only a part of the inner gill, and in the slightly *anterior* location. But the marsupial part is *very small*, occupying about one-fifth or one-fourth of the length of the gill, leaving a considerable portion non-marsupial at the anterior end, and half or nearly half at the posterior end. The figure on Pl. XLVI, fig. 1, represents a specimen with a rather small marsupium; generally it is a little larger. Thus the marsupium is in the middle of the gill, and slightly in advance of the middle. When charged, it forms here a rounded or oval swelling, rather distant from the base, and extending not quite to the edge. There is a slight variation in the specimens from the two main localities. In those from Mogy das Cruzes it is distinctly in front of the middle; in those from Mogy Mirim more median, but this difference is very slight and not always distinct. The interlaminar connections form interrupted septa (also seen in the section, Pl. XLVIII, fig. 1), and there is no distinctly reticulate arrangement.

*Glochidium* (Text-fig. 4*f*, p. 469) rather large, subtriangular, oblique, with hooks. L. 0.32, H. 0.27 mm.; hooks about 0.10 mm. long. (Thus the glochidium is slightly larger than in any of the preceding species.)

[16] The name *suppositus* was first given by Von Ihering (1893, p. 102) without description, from Rio Grande (Upper Paraná, boundary between São Paulo and Minas Geraes).

### 4. Group of *Diplodon charruanus*.

Shell not compressed, but rather evenly convex and often considerably swollen when old. Outline subelliptical or somewhat subtrapezoidal, elongate, more or less pointed behind, straight, and not oblique. Beak-sculpture simple, with narrow, straight, uninterrupted bars, restricted to the region of the beaks. A few of these bars may be joined at their lower ends.

The chief character by which this group is distinguished from that of *chilensis* is the absence of a flattening of the valves upon the sides. The valves are generally evenly convex, and in consequence of this, at least in larger specimens, the shell appears as more swollen. In other respects, the shell is similar in outline and other characters, except that the posterior end is often produced into a distinct blunt point, which may be more or less elevated above the base-line. There is no distinct tendency of the posterior portion of the shell to be higher than the anterior, and thus the shell is not oblique. A posterior ridge may be distinct or indistinct.

The first species, *D. parallelopipedon*, (Lea) froms a transition toward the group of *chilensis*.

The metropolis of these forms is in the system of the Rio de la Plata, but they are also found in the coastal streams of southern Brazil (Rio Grande do Sul).

### 13. Diplodon parallelopipedon (Lea) (1834).

*Unio parallelipipedon* D'Orbigny, 1843, p. 609; Corsi, 1900, p. 447, fig. 30.
*Diplodon parallelipipedon* Simpson, 1914, p. 1275.
*Unio parallelopipedon* Von Martens, 1894, p. 164; Pilsbry & Rush, 1896, p. 30.
*Diplodon acutirostris* (Lea) Simpson, 1914, p. 1276.
*Diplodon parallelipipedon* and *acutirostris* Haas, 1913, pp. 22, 23, 52, 53.

*Type-locality.*—Rio Paraná, Province of Corrientes, Argentina.

*Other Localities.*—Arroyo del Rosario, Uruguay (to La Plata) (D'Orbigny); Arroyo de las Vaccas, Uruguay (Corsi); Rio de la Plata, Colonia, Uruguay (Pilsbry & Rush); Rio Uruguay, Salto Oriental, Uruguay (Haas); Swamps of Rio Paraná from Buenos Aires to above Corrientes, Argentina (D'Orbigny); Rio Paraguay (Von Ihering, 1893, p. 119); Paraguay (Von Martens); Rio de San Miguel, Prov. of Chiquitos, Bolivia, (D'Orbigny).

The last locality deserves special attention, since it is in the Amazons-drainage; but it is in the most southern extremity of it, close to the divide toward the Paraguay. It certainly requires confirmation.

*New Localities.*—Rio Uruguay (in mud), Uruguayana, Rio Grande do Sul,

Brazil (J. D. Haseman coll., February 5. 1909). One specimen, male, with soft parts. Pond along Rio Negro, Santa Isabel, Uruguay (J. D. Haseman coll., February 11. 1909). Four complete shells, and five isolated valves; of two of these soft parts, males.

*Distribution.*—Drainage of the Rio de la Plata from its mouth and its tributaries in Uruguay and southern Brazil up to the Rio Paraguay in Paraguay. Also reported as crossing the divide, and going into the headwaters of the Amazons in Bolivia. Not known from the Paraná above Corrientes.

This is a species easily recognized by the elongated-subtrapezoidal shape, with the upper and lower margins nearly parallel, by the anterior position of the beaks, by the rather swollen shell and distinct (although rounded) posterior ridge. The sides of the disk are rather flattened, and in this respect this species resembles the *chilensis*-group, intergrading with it to a degree. My specimens are somewhat variable in shape, being longer or shorter. None of them shows the beak-sculpture, since the beaks are badly eroded in all, except in the specimen from Uruguayana, where they are only a little eroded, and consequently a little more elevated. But here also no beak-sculpture can be seen. It must occupy only a very short space near the beaks, hardly more than 5 mm. The specimen from Uruguayana has the nacre suffused with red (already mentioned by D'Orbigny).

There is not the slightest question that *U. acutirostris* Lea is an old, much eroded, and somewhat distorted specimen of this species. Haas has already suggested this.

*Anatomy.*—I have only the soft parts of male specimens, but Lea has already described them in the case of his *D. acutirostris*, and has furnished at least some information about the marsupium.

Judging from my material, the anal opening is closed above without forming a supra-anal. Closed part over five times as long as the open, the latter slit-like, short, shorter than the branchial opening. Inner edge of anal indistinctly crenulated. Anal and branchial separated by a solid bridge, running a certain distance inward. Branchial with fine papillæ, about three times as long as anal. Mantle-edges not united in front of it. Palpi subtriangular, lower margins convex, posterior margins connected for about one-fourth or one-third of their length.

Gills long and rather narrow. In their posterior part they are of equal width, or the outer one is slightly wider; anteriorly the inner is much wider. The outer is considerably narrowed anteriorly, its anterior end being situated near the highest point of the line of the attachment of the mantle. The inner gill has a straight margin in the middle, and anteriorly it is only slightly narrower, its anterior end

being immediately behind the palpi. Inner lamina of inner gills entirely connected with abdominal sac. Structure of the gills in the male as usual, but the interlaminar tissue is unusually well-developed, forming a rather thick layer chiefly on the inside of the primary limb of the gill; and it has, as usual, short, interrupted interlaminar connections, elongated in the direction of the gill-filaments, which in the middle of the gill are few and far apart, while they are a little more frequent near the ends.

Lea describes the marsupium (of *acutirostris*) as occupying nearly the whole length of the inner gill, but no information is given as regards the finer structure.

Color of foot brown or blackish in the distal part, otherwise the soft parts are whitish.

### 14. Diplodon charruanus (D'Orbigny) (1835).

*Glochidium:* Text-fig. 4*g*, p. 469.

*Unio charruana* D'Orbigny, 1843, p. 606, Pl. 71, figs. 8–11; Pilsbry & Rush, 1896, p. 81; Corsi, 1900, p. 447, fig. 31.

*Unio faba* (as form of *charruana*) D'Orbigny, 1843, p. 606 (text), as *rhuacoica*, Pl. 71, figs. 12–14 (*in tabula per errorem*, see Explanation of plates, p. 704).

*Unio rhuacoica* D'Orbigny, 1843, p. 606, Pl. 69, figs. 4, 5; Corsi, 1901, p. 450, fig. 33.

*Unio æthiops* Lea, Obs., X, 1863, Pl. 41, fig. 285 (*juv.*).

*Unio parcus* Lea, Obs., XII, 1869, Pl. 33, fig. 77 (*juv.*).

*Diplodon rhuacoicus, charruanus, æthiops, parcus,* Simpson, 1914, pp. 1242, 1243, 1247, 1256.

*Diplodon hidalgoi* Haas, 1916, pp. 18, 49, Pl. 1, fig. 1.

*Diplodon parcus* Haas, 1916, pp. 16, 49.

*Diplodon fortis* Marshall, 1917, p. 382, Pl. 52, figs. 1–4.

*Type-locality.*—Small streams from Maldonado and Montevideo to Las Vacas, Uruguay ("Banda Oriental").

*Other Localities.*—Lake Potrero, Maldonado, Uruguay (Pilsbry & Rush); Rio Canelon Grande, Montevideo (D'Orbigny, *rhuacoica*); Dep. Canelones, Uruguay (Corsi); Rio Miguelete, Uruguay (Haas, *hidalgoi*); Rio Negro, Tacuarembo, Uruguay; correctly S. Fructuosa, on Rio Tacuarembo, tributary to Rio Negro (Marshall, *fortis*); Uruguay River (Lea, *æthiops*).

*New Locality.*—Pond along Rio Negro, Santa Isabel, Uruguay (J. D. Haseman coll., February 11. 1909). About twenty-five specimens, seventeen with soft parts, including males and gravid females.

*Distribution.*—Small streams of the "Banda Oriental" in Uruguay, from Maldonado westward, and also in the Rio Negro and the Rio Uruguay.[17]

An extremely variable form, of which I possess a good set from one locality, undoubtedly representing young and adult specimens of the *same* species, so that I am able to give a rather full account of it. It is very evident that different individual phases have been previously described as separate species.

*Characters of Shell.*—Shell of medium size (maximum length according to D'Orbigny, 70 mm.; my largest is 62 mm.), solid and rather heavy. Outline subtrapezoidal, more or less elongated, straight (not oblique), but very variable. The upper margin may be rather straight (chiefly in young ones), or more or less curved (in older ones), with or without a distinct posterior upper angle. The posterior end of the shell is more or less pointed; the position of the point is variable, but generally rather low, and little elevated above the base-line. The lower margin is gently curved, often nearly straight in part (chiefly so in old shells), and never curved up suddenly in its posterior part, but only gently and gradually so, if at all. The posterior end of the shell is thus distinctly more tapering than the rounded anterior end, the posterior point lying rather low. The proportion of height to length of the shell is very variable, ranging from 48 to 65 pr. ct.

Valves quite convex and swollen, hardly flattened upon the sides, but more convex anteriorly and over the posterior ridge, which is blunt, but more distinct towards the beaks (and in young shells). Diameter 34 to 50 pr. ct. of length. Beaks a little inflated, but not very prominent, located at 21 to 29 pr. ct. of length. Beak-sculpture seen only in my youngest specimens, extending not more than 8 mm. from the point of the beak, consisting of about thirteen radial bars, of which only the lower ends are seen. They increase little in length posteriorly, are rather sharp in front, but the longest are somewhat obtuse, while the two last, right upon the posterior ridge, are again sharp and shorter. In some of my specimens, chiefly the younger ones, there are some short, oblique wrinkles (one to eight) upon the posterior slope; in others they are entirely absent. Lunula absent or present, narrow.

Epidermis with numerous, irregular, finer and coarser, concentric lines; the finer ones sublamellar on posterior slope and towards the margin. Radial sculpture obscure, but present in the shape of fine lines, sometimes more distinct on the anterior portion of the shell. Color of epidermis dark olive-green to black.

[17] Von Ihering (1893, p. 102) reports *æthiops* from the Guahyba drainage in Rio Grande do Sul, and a variety (*piracicabana*) from the Upper Paraná-drainage in São Paulo, but these records should be doubted.

Old specimens are generally uniformly black; younger ones are dark greenish olive or brownish olive, sometimes with more or less distinct concentric lighter (brownish to yellowish) bands.

Hinge-line gently or more strongly convex. Ligamental sinus over the posterior part of the lateral teeth; in larger specimens over the last fifth. Laterals rather straight in young, curved in older shells, one in right, two in left valve, their edges somewhat rough. Pseudocardinals normally two in right, and one in left valve, but often there is a second (posterior) one in the left valve. These teeth are extremely variable. In younger shells they are compressed and lamellar, directed obliquely forwards; the posterior tooth of the right valve is always thicker and higher than the anterior, and they are, chiefly the former, crenulated or denticulated. In older shells, the posterior tooth of the right, and the (anterior) tooth of the left valve may become thicker, more stumpy, and may be much divided. The posterior tooth of the left valve, if present at all, may be larger or smaller, compressed or stumpy.

Cavity of shell and beaks moderate. Nacre in all my specimens white, iridescent posteriorly. Anterior adductor-scar distinct and impressed; anterior retractor-scar separated from it, small and deep; anterior protractor-scar connected with it. Posterior adductor-scar less impressed, the posterior retractor-scar forming an upper process of it. Pallial line distinct. Dorsal muscle-scars a few, situated in the beak-cavity.

MEASUREMENTS.

| No. | Sex. | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|---|
| 14....... | ♂ | 34 mm. | 20.5 mm. =60 pr. ct. of L. | 12 mm. =35 pr. ct. of L. | at 10 mm. =29 pr. ct. of L. |
| 12....... | ♂ | 48 " | 26.5 " =55 " | 20 " =41 " | 10 " =21 " |
| *c*....... | ♂ | 54 " | 35 " =65 " | 27 " =50 " | 14 " =26 " |
| 9....... | ♀ | 54 " | 30.5 " =56 " | 24 " =44 " | 13 " =24 " |
| Half shell....... | | 58 " | 31 " =53 " | 26 " =45 " | 13 " =22 " |
| 3....... | ♀ | 61 " | 35 " =57 " | 26 " =42 " | 17.5 " =29 " |
| *z*....... | | 62 " | 35 " =56 " | 27 " =44 " | 15 " =24 " |

For comparison I give here previous measurements.

| | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|
| *charruanus*, D'Orbigny's text: | 70 mm. | 61 pr. ct. of L. | 45 pr. ct. of L. | |
| *rhuacoicus*, D'Orbigny's text: | 63 mm. | 51 pr. ct. of L. | 43 pr. ct. of L. | |
| *faba* (*rhuacoicus*), D'Orbigny's fig. | 43 " | 20.5 mm. =48 " | 15 mm. =35 " | 12 mm. =28 pr. ct. of L. |
| *æthiops*, Lea's fig. | 53 " | 28 " =53 " | 18 " =34 " | 12 " =23 " |
| *parcus*, Lea's fig. | 36 " | 18 " =50 " | 13 " =36 " | 10 " =28 " |
| *hidalgoi*, Haas: | 63 " | 39 " =62 " | 27 " =43 " | |
| | 66.5 " | 42 " =63 " | 27 " =41 " | |
| *fortis*, Marshall: | 66 " | 37 " =56 " | 27 " =41 " | |

*Remarks.*—Among our specimens the single valve comes nearest to the measurements given for *U. rhuacoicus.* D'Orbigny himself admits that this may be only a more elongated form of *charruanus,* and his *faba,* united by him with *charruanus,* is even more elongated. There is no reason for keeping *rhuacoicus* separate, since the proportional length is said to be the only difference.

The variations in the shape of the shell are, indeed, very great. Younger specimens are, however, more uniform; they are more elongated, and their normal shape is well rendered in D'Orbigny's figures of *faba* (Pl. 71, figs. 12–14), and in the figures of *æthiops* and *parcus.* The latter undoubtedly is a young shell, but *æthiops* also belongs here. Specimens like those measured under Nos. 12 and 9 resemble this very much, except that they are a little more swollen, and our smallest (No. 14) looks very much like *parcus,* but it is less elongated.

In the description and the figures of D'Orbigny only the color of the epidermis is not exactly as in our specimens. D'Orbigny describes it in *charruanus* as well as *rhuacoicus* as brownish green, and figures it as lighter or darker brown, while the color of *faba* (Pl. 71, figs. 13, 14) is blackish, agreeing better with our specimens. However, our young specimens have a color, which may be called brownish green, or rather "olive-brown." Lea's *æthiops* is said to be black.

The chief characters of this species thus seem to be the subtrapezoidal, rather elongate, straight shell, with a moderately sharp posterior point, located only little above the base-line; the somewhat swollen shell, with a moderate and blunt posterior ridge, and the brown to blackish color of the epidermis. The chief variations are found in the length of the shell, and the somewhat higher or lower position of the posterior end.

There is no question that *hidalgoi* Haas and *fortis* Marshall are this species. The former is founded upon two specimens, the latter upon a single one, which certainly represent individual phases. Specimens greatly resembling these are among my material.

*Anatomy.*—I have the soft parts of eleven males and six gravid females, three with eggs, three with glochidia, one of these discharging.

Anal opening slit-like, closed above, the closed part about four times as long as the opening; the latter shorter than the branchial opening. The two openings are separated by a solid mantle-connection. Branchial with small papillæ. Palpi subtriangular, their posterior margins connected near the base. Gills posteriorly of about the same width, but anteriorly the inner is wider, and its anterior end is immediately behind the palpi. Inner lamina of inner gill entirely connected with abdominal sac. Non-marsupial gills with scattered, short, interlaminar connec-

tions. The *marsupial part* of the female occupies a large portion of the inner gill, leaving about one-fourth of the gill free in front, and a smaller part free behind, thus gravitating slightly toward the posterior part of the gill. The interlaminar connections could not be distinctly observed by me on a lateral view, since no barren females are at hand; but from sections it was possible to infer that they form interrupted septa forming a system of intercommunicating water-tubes. The eggs and glochidia fill the water-tubes and the perforations of the septa in a mass, which is not conglutinated and divided into placentæ.

The *glochidium* (Text-fig. 4*g*, p. 469) has the characteristic triangular shape, somewhat oblique, with the point situated below the posterior end of the upper margin (like the figure of the glochidium of *U. peculiaris*, See Lea, Obs. XII, 1869, Pl. 34, fig. 80). *This point does not possess a hook.* Size of glochidium: L. 0.31, D. 0.26 mm.

I have examined the glochidia of three specimens; one of these had the marsupium largely empty, and thus it appears to have been discharging. Yet no hooks were seen. But it may be that the discharge in this case was premature, that none of the glochidia were mature, and that the hooks might have developed later. This can be decided only by investigating more material.

### 15. Diplodon piceus (Lea) (1860).

*Anatomy of gills:* Pl. XLVI, fig. 2; *glochidium:* Text-fig. 4*h*, p. 469.

*Unio piceus* Lea, Obs., X, 1863, Pl. 41, fig. 287.

*Diplodon piceus* Simpson, 1914, p. 1244; Haas, 1916, pp. 15, 49.

*Type-locality.*—Uruguay River.

*Other Localities.*—Rio Uruguay, Salto Oriental, Uruguay (Haas); Rio Miguelete, Uruguay (Haas).

*Localities Represented in the Carnegie Museum.*—Rio Uruguay (in mud), Uruguayana, Rio Grande do Sul, Brazil (J. D. Haseman coll., February 5, 1909) eight specimens, seven of them with soft parts, males and gravid females. Arroyo Miguelete, Montevideo, Uruguay (J. D. Haseman coll., February 17,1909) one specimen.

*Distribution.*—Positively known from the Uruguay River, and from a small coastal stream (R. Miguelete) near Montevideo, and probably more widely distributed in the "Banda Oriental" in Uruguay. It possibly may be only a form of *charruanus.* Corsi does not mention it from Uruguay.

A species closely allied to *D. charruanus,* and very near to it in its dimensions, except that it does not show the same extremes of variation. It is, however,

shorter on the average (H. 59 to 63 pr. ct. of L., while *D. charruanus* varies from 48 to 65 pr. ct.). In addition *D. piceus* is not so subtrapezoidal in outline, but rather subovate, which is brought about by a stronger curve of the lower margin, which ascends much more distinctly posteriorly, so that the posterior end of the shell is more elevated above the base-line. At the same time the posterior end is rather blunt and rounded, and not so pointed as in *D. charruanus.*

All other characters of the shell are similar to *D. charruanus.* The radial sculpture of the epidermis is more distinct. The inside of the shell is also similar, but the pseudocardinals are simpler, always elongate and compressed, and there is always only one in the left valve. They are not much cut up, but only crenulated and rugose. Nacre white, though one of my specimens has purplish blue in the cavity, probably a discoloration.

Beak-sculpture, as far as can be seen in smaller shells, similar to that of *D. charruanus.* But there is a very small specimen, which is only 10 mm. long, among them, which is doubtfully referred here. In this case the sculpture consists of fifteen radial bars, of which the eighth and ninth unite at their lower ends. The anterior bars are shorter, but there is not much difference in this respect from the posterior bars. The bars are rather sharp and fine, but those upon the umbonal ridge are slightly thicker, and the two last, upon the posterior slope are very fine and shorter.

MEASUREMENTS.

| No. | Sex. | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|---|
| *Uruguayana.* | | | | | |
| 1........ | ♀ | 30 mm. | 19 mm. =63 pr. ct. of L. | 11.5 mm. =38 pr. ct. of L. | at 8.5 mm. =28 pr. ct. of L. |
| 2........ | ♀ | 35 " | 20.5 " =59 " | 13 " =37 " | 10 " =29 " |
| 5........ | ♂ | 51 " | 31 " =61 " | 21 " =41 " | 15 " =29 " |
| 4........ | ♀ | 51.5 " | 30 " =58 " | 20.5 " =40 " | 15 " =29 " |
| 7........ | ♀ | 64 " | 38 " =59 " | 28 " =44 " | 18 " =28 " |
| *Montevideo.* | | | | | |
| | | 57 " | 35.5 " =62 " | 25.5 " =45 " | 16 " =28 " |
| Lea's fig. | | 47 " | 28 " =60 " | 19 " =40 " | 12 " =26 " |

*Remarks.*—There is not the slightest doubt that my specimens represent the *U. piceus* of Lea, but the question of its possible identity with *D. charruanus* must be left undecided, also that of other possible synonyms (*lepidus* Lea, and *firmus* Lea). I cannot unite these for the present on account of certain peculiar structures in the anatomy, which will be pointed out presently.

*Anatomy.*—I have the soft parts of one male, one barren female, and five gravid females, three of the latter with eggs, and two with glochidia, but in one only are the glochidia mature.

The structure is entirely like that of *D. charruanus.* With regard to the *mar-*

*supium* (Pl. XLVI, fig. 2) it is to be remarked that it occupies in larger specimens a somewhat greater portion of the inner gill, leaving anteriorly as well as posteriorly less than one-fourth of the gill free. In smaller females the marsupial part is relatively smaller. The interlaminar connections form distinct, but interrupted, septa. The connections stand very close, and the septiform structure prevails throughout the marsupium, and very little is seen of a transverse or reticulate arrangement. In some parts, chiefly towards the margin, the septa become more or less continuous. Thus there are here rather distinct, but intercommunicating water-tubes (ovisacs), which are filled, when charged, with masses of eggs connected with each other through the communications, so that no placenta-like arrangement is observed.

*Glochidium* (Text-fig. 4*h*, p. 469).—Higher and more upright than that of *D. charruanus*; L. and H. about the same, 0.28 to 0.29 mm. Thus it is more like that of *D. firmus* figured by Lea (Obs., XII, 1869, Pl. 34, fig. 82), but not quite as upright. At the point of the lower margin there is a *hook* of the usual shape, about 0.09 mm. long. But such hooks are present in only one of my specimens, in the other the glochidia are too immature.

It would be quite remarkable if in two species, so closely allied as *D. charruanus* and *piceus*, the glochidia should differ so fundamentally, that in one there are hooks, and in the other not. But judging from my material, this is the case. However, it must be emphasized again that my material is scanty, and possibly in the case of *D. charruanus* I do not at all have ripe glochidia.

### 16. Diplodon uruguayensis (Lea) (1860).

*Unio uruguayensis* Lea, Obs., X, 1863, Pl. 45, fig. 298.
*Diplodon uruguayensis* Simpson, 1914, p. 1234.
*Unio apprimus* Lea (1866), Obs., XII, 1869, Pl. 33, fig. 78.

*Type-locality.*—Uruguay River.

*New Locality.*—Pond along Rio Negro, Santa Isabel, Uruguay (J. D. Haseman coll., February 11, 1909). Five complete specimens, and several odd valves, two specimens (male and female) with soft parts.

*Distribution.*—Known only from Rio Uruguay and Rio Negro.

The synonymy and affinity of this species is obscure. Simpson thinks that it is close to *D. wymani*, but the latter is a compressed shell, while *uruguayensis* is much swollen. *U. apprimus* also is a swollen shell. Lea has already suggested that this is close to *uruguayensis*, but that it differs chiefly in the hinge-teeth,

which are more lamellar and compressed in the latter (a smaller shell), and more stumpy and cut up in *apprimus*. My material shows that the character of the hinge-teeth changes with age. In general my specimens correspond in size and shape to *uruguayensis*, but the larger ones have more stumpy teeth, and thus I believe that *apprimus* is an old specimen of *uruguayensis*. Both Simpson and Haas (1916, p. 12, 47) unite *apprimus* with *wymani*, which cannot be correct on account of the difference in obesity. I think *wymani* belongs to *lacteolus* (See below).

However, it is quite possible that all these forms are variations of one and the same species, and then, of course, our general arrangement must be changed. As regards the present form I can only say that it looks like a very large and heavy *charruanus*, the shell being rather elongated, subtrapezoidal, and much swollen. In *lacteolus*, the shell is higher and more ovate, and much more compressed. In none of my specimens is the beak-sculpture seen.

MEASUREMENTS.

| No. | Sex. | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|---|
| *a*........ | | 73 mm. | 50 mm. =68 pr. ct. of L. | 31 mm. =43 pr. ct. of L. | at 19 mm. =26 pr. ct. of L. |
| 1........ | ♂ | 73.5 " | 47 " =64 " | 37 " =50 " | 20 " =27 " |
| *b*........ | | 78 " | 52 " =67 " | 40 " =51 " | 21 " =27 " |
| 2........ | ♀ | 78 " | 52 " =67 " | 33 " =42 " | 19 " =24 " |
| *c*........ | | 79 " | 47.5 " =60 " | 32 " =41 " | 20 " =25 " |
| *uruguayensis*..... | | 70 " | 45 " =64 " | 30 " =43 " | |
| *apprimus*[18]....... | | 101 " | 66 " =65 " | 40 " =40 " | |

*Anatomy.*—Soft parts of a male and a barren female at hand.

Color of soft parts: distal part of foot dark gray, this color sharply marked off from the whitish basal part.

Anal closed above; closed part about four times as long as the open part, which is slit-like, and shorter than the branchial, and separated from it by a solid mantle-connection. Branchial opening with small, but distinct, papillæ. Palpi rather large, subtriangular, with lower margins strongly convex; posterior margins connected at base.

Gills long and moderately wide, the inner one much wider than the outer anteriorly, its anterior end immediately behind the palpi. Inner lamina of inner gill entirely connected with abdominal sac. Non-marsupial gills with scattered, short, interlaminar connections. In the female a large section of the inner gill is *marsupial*, about one-fourth of the gill remaining non-marsupial at the anterior

[18] The measurements of *uruguayensis* and *apprimus* are those given by Simpson for the respective types. Those for *apprimus* are given by him under *wymani* (p. 1231).

end, and less than that at the posterior end. The interlaminar connections of the marsupium are developed as interrupted septa, forming communicating water-tubes. The connections are short, and are also arranged in irregular cross-rows, but towards the edge of the gill, the septiform arrangement is quite distinct.

### 17. Diplodon hildæ Ortmann, sp. nov.

*Shell:* Pl. XXXVI, fig. 7; Pl. XXXVII, figs. 1, 2, 3; *Anatomy of gills:* Pl. XLVI, fig. 3; *Glochidium:* Text-fig. 4*i*, p. 469.

*Type-locality.*—Rio Jacuhy, Cachoeira, Rio Grande do Sul, Brazil (J. D. Haseman coll., January 26, 1909). *Type-set:* Carnegie Museum, No. 61.5864. Fourteen specimens, males, barren and gravid females, soft parts of all in alcohol.

There were six additional specimens in the original lot.

*Description of the Shell.*—Shell rather small (maximum length 46 mm.), rather solid. Outline subelliptical or indistinctly subtrapezoidal, height 57 to 63 pr. ct. of length. Upper margin straight or gently convex, forming a blunt angle with the posterior margin. Posterior margin obliquely descending, straight, or gently convex, forming a blunt point with the lower margin; this point situated distinctly above the base-line. Lower margin rather regularly convex, ascending anteriorly and posteriorly, its lowest point situated between beaks and posterior end of ligament (rather median). Anteriorly the margin is regularly rounded. Anterior end of shell not much narrower than the posterior, which tapers to the blunt posterior point, so that the shell is rather regularly elliptical, with the posterior end subpointed, the angle of the posterior upper margin giving a suggestion of the subtrapezoidal shape.

Valves rather regularly convex, greatest diameter slightly behind the middle, but distinctly in front of the posterior ridge, which is very blunt and broad. Posterior slope somewhat compressed, sometimes with a trace of a radial furrow. Sides of disk less convex, but not at all flattened. Diameter 34 to 44 pr. ct. of length, so that the shell appears as moderately swollen. Beaks a little inflated, but not very prominent above the hinge-line, located at 23 to 28 pr. ct. of the length. Beak-sculpture seen only in the smallest specimens, and only the lower part of it. There are about fourteen radial bars, the anterior rather sharp, the posterior located just in front of the posterior ridge, broader (at least their lower ends) and the latter are a little longer than the former. The last two or three bars are again finer and shorter. The longest bars are about 8 mm. long. There may be fine, short, oblique wrinkles upon the posterior slope, but these are distinct only in a few specimens. Lunula short, very narrow, or practically absent.

Epidermis shining, chiefly so in the middle of the disk and in younger specimens, but with unequal concentric wrinkles and striæ, which become somewhat sublamellar on the posterior slope and near the margins. Radial sculpture present, consisting of irregular, often interrupted lines, chiefly upon the anterior part of the shell, often appearing as "scalariform stripes" (radial rows of fine, short, concentric wrinkles). Color of epidermis light to dark brown; in young specimens it is a beautiful, shining, golden brown, lighter in the middle of the shell and towards the beaks (and sometimes here with light greenish shades). In older shells the color is chestnut-brown to dark brown. In some specimens there are indications of darker concentric bands. No traces of color-rays, except one or two very faint dark rays upon the posterior slope (seen only when held up against a strong light).

Hinge-line very gently curved. Ligamental sinus over the posterior fourth or third of the lateral teeth (more posterior in old shells, which shows that the ligament is comparatively longer in them). Lateral teeth gently curved, long, one in right, two in left valve, finely rugose. Pseudocardinals obliquely directed forward and downward, normally two in right, one in left valve, compressed, but not very long, their edges crenulated and serrated. The posterior in the right valve more elevated than the anterior, and often thicker. Sometimes there is a trace of a second posterior tooth in the left valve, but this is always small.

Cavity of shell and beaks moderately deep. Nacre whitish, shining, in the largest specimens the thickest parts (toward the front of the shell) have a faint rosy hue. Muscle-scars of the typical shape; the anterior adductor-scar is rather deep, the retractor-scar separated from it, round and deep, the protractor-scar connected with it; the posterior adductor- and retractor-scars are united. Pallial line distinct. An irregular, longitudinal row of dorsal scars in the beak-cavity.

MEASUREMENTS.

| No. | Sex. | Length. | Height. | Diameter. | Beaks. | Figured. |
|---|---|---|---|---|---|---|
| d... | ♂ | 25 mm. | 14.5 mm. =58 pr. ct. of L. | 8.5 mm. =34 pr. ct. of L. | at 7 mm. =28 pr. ct. of L. | Pl. XXXVII, fig. 1. |
| c... | ♀ | 32.5 " | 19.5 " =60 " | 11.5 " =35 " | 7.5 " =23 " | |
| k... | ♂ | 37.5 " | 23.5 " =63 " | 15.5 " =41 " | 10 " =27 " | |
| p... | ♀ | 40 " | 24 " =60 " | 16.5 " =44 " | 10.5 " =26 " | |
| q... | ♂ | 43 " | 24.5 " =57 " | 17 " =40 " | 10 " =23 " | Pl. XXXVI, fig. 7. |
| 15... | ♀ | 46.5 " | 27 " =58 " | 19 " =41 " | 11.5 " =25 " | Pl. XXXVII, fig. 2. |

*Remarks.*—I have been unable to recognize this species in any of the published descriptions. It is a rather beautiful shell; marked by its small size, nearly regularly elliptical outline, with no obliquity, rather swollen valves, and with a peculiar, shining, golden brown color when young. It resembles, to a degree, *D. charruanus*, but differs from it chiefly in size, more regular shape, and the gloss of the epidermis.

Very few species of *Diplodon* are known in Rio Grande do Sul, from the drainage of the Guahyba (to which the Rio Jacuhy belongs) and all have been only incidentally mentioned by Von Ihering (1893). Under *U. æthiops piracicabana* (*l. c.*, p. 102) he reports that *U. æthiops* is found in the Guahyba River. I have been unable to discover this species, which is identical with *charruanus*, in the material collected by Haseman in this system, and I am sure that the present form is *not* the one which Von Ihering calls *æthiops*. From his casual remarks it is seen that the latter has a shallow depression on the disk (*l. c.*, p. 104), and nothing of the kind is seen in *D. hildæ*.

*Anatomy.*—I have two barren females, and three gravid females with glochidia. Of the latter, one had only very few glochidia in the marsupium, but some were in the suprabranchial canals, and thus it was evidently discharging. The rest of my specimens are males.

Color of soft parts whitish; distal part of foot grayish black.

Anal opening closed above; closed part about four times as long as the open part, the latter slit-like, slightly shorter than the branchial; the latter has small, but distinct papillæ. Anal and branchial openings separated by a solid mantle-connection. Palpi moderate, subtriangular, posterior margins connected at base.

Gills long and rather wide. They are about equally wide posteriorly, but the outer is subtriangular and narrows anteriorly, while the inner does not, and remains as wide as posteriorly, with its anterior end immediately behind the palpi. Inner lamina of inner gill entirely connected with abdominal sac. The non-marsupial gills with scattered interlaminar connections. In the female, the *marsupium* (Plate XLVI, fig. 3) is located in the inner gill, but anteriorly about one-third of the gill remains non-marsupial, posteriorly much less, about one-fifth of it or less, so that the marsupial part is located distinctly more backward in the gill, occupying about half of its length. When charged, the marsupium forms a slightly swollen patch. In young specimens the marsupium is smaller. Interlaminar connections in the marsupium forming septiform rows, with a tendency to fall also into irregular transverse rows. The transverse arrangement prevails near the base and in the middle of the gill, here and there with a suggestion of a quincuncial disposition; the septiform arrangement is found toward the margin of the gill.

*Glochidium* (Text-fig. 4*i*, p. 469) subtriangular, longer than high, with a ventral point, slightly oblique, the point being vertically under the posterior end of the upper margin. There are *no hooks.* In one of my specimens, the glochidia are not margined (not mature); in the two others they are *margined,* with a narrow

rim around the anterior-lower-posterior margin, representing, apparently, the first rudiments of the postembryonal shell. Size (without rim): L. 0.29 to 0.30; H. 0.26 mm.; (with rim): L. 0.34 to 0.35; H. 0.28 to 0.29 mm.

The hookless glochidium, provided with a rim or margin, is highly interesting in view of the fact, that this structure has not been observed in other species of the *charruanus*-group.

### 5. Group of *Diplodon lacteolus*.

Like the fourth group (that of *charruanus*), but shell higher and shorter, subtrapezoidal to ovate, chiefly so when young, compressed or somewhat swollen. Beak-sculpture fine or a little heavier and better developed, but not covering a large part of the shell.

This group stands close to that of *D. charruanus*. The greater height of the shell is chiefly evident in the young shell, which may be slightly oblique. But the older shells are also shorter and higher than in the species of the *charruanus*-group, although they generally are less elevated than younger shells. They are not oblique, and have a rather regular, broadly ovate, or subelliptical outline.

### 18. Diplodon burroughianus (Lea) (1834).

*Anatomy of gills:* Plate XLVI, fig. 4.

*Unio burroughianus* Lea, Obs., I, 1834, Pl. 10, fig. 27; D'Orbigny, 1843, p. 609; Von Martens, 1894, p. 164; Corsi, 1901, p. 450.

*Diplodon burroughianus* Simpson, 1914, p. 1271.

*Type-locality.*—Rio Paraná, Province of Corrientes, Argentina.

*Other localities.*—Small rivers of the Banda Oriental in Uruguay (D'Orbigny); Montevideo (D'Orbigny); swamps along the Paraná from Buenos Aires to above Corrientes (D'Orbigny); Paraguay (Von Martens).

It also occurs near Santa Cruz de la Sierra in Bolivia (D'Orbigny) which is in the drainage of the Amazons.

*New Locality.*—Pond near the Rio Negro, Santa Isabel, Uruguay (J. D. Haseman coll., February 11, 1909). Three complete specimens, two of them, male and female, with soft parts, and four odd valves.

*Distribution.*—Drainage of Rio de la Plata, including the small streams of the Banda Oriental, Rio Negro, and the Paraná and Paraguay to Paraguay, and possibly also in the Amazon-drainage in Bolivia. The latter part of the range, however, should be confirmed.

Some of my specimens, chiefly the female with soft parts, agree very well with

*burroughianus* in shape, dimensions, and color. Others differ more or less, chiefly in having the posterior point of the shell less elevated above the base-line. Thus they approach other species described by Lea as *piger* (1860) and *ampullaceus* (1869), both from the Uruguay River (See also *ampullaceus*, Haas, 1916, pp. 11, 47). My material is not sufficient to work out the synonymy.

MEASUREMENTS.

| Sex. | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|
| ♀ | 54 mm. | 38 mm. = 70 pr. ct. of L. | 23.5 mm. = 44 pr. ct. of L. | at 13 mm. = 24 pr. ct. of L. |
| ♂ | 56.5 " | 39 " = 73 " | 27.5 " = 49 " | 15 " = 27 " |
| | 60 " | 44 " = 73 " | 26 " = 43 " | 16 " = 27 " (Lea's figure) |
| | 100 " | 62 " | 44 " | (D'Orbigny) |
| | 94 " | 64 " = 68 " | 40 " = 43 " | (Von Martens) |
| | 88 " | 58 " = 66 " | 35 " = 40 " | (Simpson) |
| | 71 " | 43 " = 61 " | 26 " = 37 " | Do. |

The two specimens measured by Simpson do not include the type. They are more compressed than any others.

*Anatomy.*—The soft parts of a male and a female are at hand.

Color of soft parts whitish, distal part of foot grayish.

Anal opening slit-like, closed above, short, shorter than the branchial opening, separated from the latter by a connection of the mantle-margins. Branchial opening short, its inner edge with small, but distinct papillæ. Palpi subtriangular, moderately large, lower margins convex, posterior margins united at base for a short distance.

Gills of the usual shape; the inner the wider, chiefly in front, its anterior end close behind the palpi. Structure of non-marsupial gills as usual. Marsupial portion in the female (Pl. XLVI, fig. 4) located in the inner gill, leaving about one-third at the anterior end, and about one-fifth at the posterior end free, so that the marsupium distinctly gravitates toward the posterior part of the gill. Interlaminar connections arranged in interrupted septa, and irregular, transverse rows, here and there quincuncial. This irregularly reticulate structure prevails throughout the marsupium, and the septiform arrangement is obscure.

### 19. Diplodon lacteolus (Lea) (1834).

See: *Diplodon lacteolus* (Lea) and *D. wymani* (Lea) (1860) Simpson, 1914, p. 1226, 1230.[19]

[19] Lea himself (1834, p. 90) has identified the type of Lamarck's *U. delodonta* (1819) with his *lacteolus* (1834, p. 40), but not until after the latter name had been published in a satisfactory way, while the original description of *delodonta* is absolutely unidentifiable. Thus, according to the rules, *lacteolus* must be used, as Simpson has done.

The following references should be added to those given by Simpson.

*Unio delodonta* D'ORBIGNY, 1843, p. 605; Corsi, 1901, p. 449.

*Diplodon wymani* HAAS, 1916, pp. 12, 47.

As to the synonymy compare Simpson. His *D. wymani* only in part belongs here. *D. apprimus* Lea, united by him with *wymani*, is different (more swollen, see above p. 512). On the other hand, I cannot distinguish the real *wymani* from *lacteolus*, and Von Ihering (1893, p. 117) also unites them.

*Type-locality.*—Rio de la Plata.

*Other Localities.*—Stream, Villa del Cerro, Montevideo, Uruguay (D'Orbigny); Rio Uruguay (Lea, *wymani*); Rio Uruguay, Las dos Hermanas Islands, Uruguay (D'Orbigny); Rio Uruguay, Salto Oriental, Uruguay (Haas); Rio San Salvador (trib. to Uruguay), Soriano, Uruguay (Corsi); Buenos Aires (D'Orbigny); Rio Batel and Rio Corrientes, Province of Corrientes, Argentina (D'Orbigny).

*New Localities.*—Pond near Rio Negro, Santa Isabel, Uruguay (J. D. Haseman coll., February 11, 1909). One specimen, young. Brooklet, two miles north of the City of La Plata, Argentina (Dr. W. J. Holland coll., September 24, 1912). Two specimens.

*Distribution.*—Lower La Plata and Paraná systems, upward to the province of Corrientes; also in the lower Uruguay and Rio Negro, and small tributaries of the La Plata in Argentina and Uruguay.

My specimens from La Plata are typical. The young specimen from Santa Isabel is interesting in having a rather high shell, which is slightly oblique, but comparison with the other specimens shows that, according to the growth-rests, the latter had the same shape when young. This young shell also exhibits the comparatively heavy beak-sculpture, with the radial bars running down the shell about 13 to 15 mm. Traces of these are also seen in my larger specimens.

MEASUREMENTS.

| | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|
| Santa Isabel | 50 mm. | 36.5 mm. =73 pr. ct. of L. | 18 mm. =36 pr. ct. of L. | at 13 mm. =26 pr. ct. of L. |
| La Plata | 85 " | 61 " =72 " | 32 " =38 " | 21 " =25 " |
| Do. | 87 " | 63 " =72 " | 34 " =39 " | 22 " =25 " |
| *lacteolus* (Lea's figure) | 80 " | 51 " =64 " | 31 " =39 " | 23 " =29 " |
| Do. (Acc. to Simpson) | 80 " | 50 " =63 " | 30 " =38 " | |
| Do. Do. | 72 " | 42 " =58 " | 26 " =36 " | |
| Do. Do. | 83 " | 56 " =67 " | 35 " =42 " | |
| *delodontus* (D'Orbigny) | 85 " | 70 " | 38 " | |
| *wymani* (Lea's figure) | 75 " | 49 " =65 " | 28 " =37 " | 19 " =25 " |

The first measurements given by Simpson apparently refer to the type of *lacteolus*, although they do not fully agree with Lea's figure. The second measure-

ments given by him belong to a specimen which is exceptionally low. The measurements given by Simpson for *wymani* do not belong to this species, but to *apprimus* (See above, p. 513, footnote 18).

I have a suspicion that *D. felipponei* Marshall (1917, p. 381, Pl. 50, figs. 1–3, Pl. 51, fig. 1) from Maldonado and other places in Uruguay, is also this species. The height as given is 70 to 72 pr. ct. of the length, and the general shape and other particulars agree, as for instance the hinge-teeth. But, according to the figure, *felipponei* is less pointed behind, and the diameter is a little greater (40 to 46 pr. ct. The color also (yellowish-chestnut) is not exactly like *lacteolus*, which has chestnut-olive-green tints. Thus I leave this question undecided.

### 20. Diplodon mogymirim Ortmann, sp. nov.

*Shells:* Pl. XXXVII, figs. 4, 5, 6, 7; *Anatomy of gills:* Pl. XLVI, fig. 5; *Section of gills:* Pl. XLVIII, fig. 2; *Glochidium:* Text-fig. 4*k*, p. 469.

*Type-locality.*—Creek near Mogy Mirim, São Paulo, Brazil, tributary to Rio Mogy Guassú and Rio Grande, upper Paraná-drainage. J. D. Haseman coll., August 28, 1908. *Type-set:* Carn. Mus. Cat. No. 61.9260, fourteen specimens, males, barren and gravid females, all with soft parts. (The original lot contained over one hundred specimens.)

Of all the species of *Diplodon* known from the upper Paraná-drainage in São Paulo only one described by Von Ihering resembles this in shape: *Unio greeffeanus* (Von Ihering, 1893, p. 96, Pl. 4, fig. 8). However, the color of the epidermis of the latter is described as being dark green to blackish, and this does not at all fit our specimens, which are brownish black, without any distinct greenish tints. Moreover, the dimensions given for the two specimens described by Von Ihering, although falling within the range of variation of my specimens, are rather extreme, and do not represent the normal condition of our species. The height is 61 and 64 pr. ct. of the length, while in my material this proportion varies from 62 to 74 pr. ct.; and the diameter is 34 and 33 pr. ct., while it ranges, in my specimens, from 32 to 42 pr. ct. *U. greeffeanus* comes from the Piracicaba River (Campinas and Piracicaba), while our specimens belong to the Rio Grande drainage.

From the latter, and especially from Rio Mogy Guassú, at Jaboticabal (not "Taboticabal" as printed), Simpson (1914, p. 1250) has described *Diplodon trivialis*. Dimensions and description agree with our specimens to a degree; but again the color is different, being described as black or dark brown, and tinted green when rubbed, while in our specimens, when rubbed (cleaned), the epidermis is of a peculiar

golden brown, without green. Also the epidermis is not at all "cloth like," as described in *trivialis* (when fresh), and the description of the pseudocardinals of the left valve does not agree at all. There are said to be two pseudocardinals, the anterior one sometimes feeble, while in our specimens there is generally only one well-developed, and this is the anterior, and if there is a smaller second pseudocardinal, this is the posterior. The figures of *trivialis* given by Marshall (1917, p. 386, Pl. 54, figs. 5–8) show also that the outline is different, being evenly rounded behind. Among my numerous specimens there is not a single one which shows this character, and thus I cannot identify them with *D. trivialis.*

*Description of Shell.*—Of moderate size (maximum length 68 mm.), rather solid. Outline short subelliptical or subovate, or subrhomboidal, when young. Height from 62 to 74 pr. ct. of length. Upper margin nearly straight when young, more or less curved when old, in the first case forming an angle with the obliquely and rather steeply descending posterior margin, in the latter case passing into it more or less gradually. Posterior margin gently concave, straight, or gently convex, forming a rounded angle with the lower margin, which may be more distinct in older shells. This posterior point is more or less elevated above the baseline. Lower margin gently and regularly curved, in older shells more nearly straight in the middle. Anterior end of shell slightly narrower than the posterior in young shells; in old shells this may be reversed. Thus the shell is, when young, more subrhomboidal, with an upper posterior angle (somewhat subalate), and, when old, the shell becomes subelliptical or subovate, with the posterior end a little tapering.

Valves rather regularly and evenly convex, sides not distinctly flattened. Greatest diameter a little anterior to the middle. Posterior ridge present, but rounded and indistinct, often (chiefly in young specimens) marked by a shallow radial groove running down the posterior slope, which thus appears as compressed and slightly elevated toward the upper-posterior margin (subalate). Diameter 32 to 42 pr. ct. of the length, so that the shell is rather compressed. Beaks not inflated and not much elevated, located at from 25 to 31 pr. ct. of the length. Beak-sculpture consisting of fine and short radial bars, hardly more than 5 mm. long, fifteen to eighteen in number, those in the middle converging at their lower ends (one or two pairs). They are hardly longer upon the posterior ridge, and not appreciably thicker. A few oblique wrinkles may be present upon the posterior slope. In most cases the beak-sculpture is entirely obliterated by erosion of the beaks, and in general it is fine, short, and poorly developed. Lunula present, narrow in young specimens, wider in old ones, but very variable.

Epidermis somewhat shining, with unequal, irregular, concentric wrinkles, more crowded and sublamellar upon the posterior slope and near the margins, chiefly in older shells. Radial sculpture may be present, but indistinct, visible chiefly upon the anterior part of the shell as "scalariform" stripes. Color of epidermis from yellowish brown to dark brown and blackish, but without any distinct traces of greenish tints. In young specimens, when well cleaned, the color is generally yellowish or golden brown in the middle of the disk, shading to chestnut-brown toward the ends and margins. Older shells are more uniformly chestnut-brown to blackish brown (often coated with a dull black-brown deposit). Slight traces of darker brown concentric bands are rarely present.

Hinge-line generally distinctly curved. Ligamental sinus over the posterior half or third of the laterals, generally very indistinct in old specimens. Lateral teeth curved (less so in young shells), moderately long, one in right, two in left valve, their edges and sides corrugated in old shells. Pseudocardinals directed obliquely downward and forward, compressed and lamellar, thin in young shells, thicker in old ones. The right valve has nearly always two of them, equally high, but the anterior narrower. The left valve has mostly only one; but there may be a small and short posterior one, and even a small and narrow anterior one. In one specimen (one out of over one hundred), the pseudocardinals are exactly reversed: one in right, two in left valve, while the laterals are normal. The edges of the pseudocardinals are rugose and crenulated, but not dissected.

Cavity of shell and beaks moderate. Nacre whitish, but very generally partially discolored, with irregular yellowish, brownish, or grayish spots. Anterior adductor-scar impressed, rounded or subtriangular; anterior retractor-scar separated from it, rounded or irregularly oval, impressed, but not remarkably deep; anterior protractor-scar connected with adductor-scar. Posterior adductor-scar ovate or subtriangular, less deeply impressed; posterior retractor-scar generally separated from it, but sometimes only indistinctly so. Pallial line distinct. Dorsal scars few and irregular, in beak-cavity, forming an indistinct longitudinal row.

MEASUREMENTS.

| No. | Sex. | Length. | Height. | Diameter. | Beaks. | Figured. |
|---|---|---|---|---|---|---|
| 49... | ♂ | 31 mm. | 22 mm. =71 pr. ct. of L. | 11 mm. =35 pr. ct. of L. | at 8.5 mm. =27 pr. ct. of L. | |
| 12... | ♂ | 39 " | 26.5 " =68 " | 12.5 " =32 " | 11 " =28 " | Pl. XXXVII, fig. 6. |
| 18... | ♀ | 40.5 " | 30 " =74 " | 15 " =37 " | 11 " =27 " | |
| 9... | ♂ | 53 " | 36 " =68 " | 20 " =38 " | 13.5 " =25 " | Pl. XXXVII, fig. 5. |
| 41... | ♀ | 63 " | 39 " =62 " | 26 " =41 " | 17 " =27 " | |
| 5... | ♀ | 64.5 " | 40 " =62 " | 27 " =42 " | 17 " =26 " | |
| 34... | ♀ | 68 " | 43 " =63 " | 25.5 " =38 " | 21 " =31 " | |
| 16... | ♀ | 68 " | 45 " =66 " | 26 " =38 " | 18 " =26 " | |

*Remarks.*—This species somewhat resembles *D. lacteolus*, but is considerably smaller, has finer and shorter beak-sculpture, and, when old, has more simple, less dissected pseudocardinals, of which those of the right-valve are more nearly equal. The young shell (Pl. XXXVII, fig. 6*a*) has rather a subrhomboidal shape, exactly as *D. lacteolus*, which is due to the better development of the angle between the upper and posterior margins, which appears as slightly elevated (alate). Thus the young shell is slightly higher in its posterior section, with the posterior end of the shell less elevated above the base-line, giving to the whole shell a slightly oblique appearance. But this juvenile shape is sooner or later obliterated, the posterior wing disappearing, and the posterior end becoming more tapering, giving to the shell a rather subovate outline, with the posterior end subpointed; but this point is never very distinct. The outline of Von Ihering's *greeffeanus* (Pl. 4, fig. 8) comes very near to the normal shape of the old shell of *D. mogymirim*. The brownish color of the epidermis of our species is also characteristic, and the complete absence of distinctly greenish tints is to be noted.

*Anatomy.*—I have a great number of the soft parts of males and of barren and gravid females, the latter partly with eggs, partly with glochidia in various stages of development. Of fifty specimens the anatomy has been investigated more closely. For the breeding season the date of collection (August 28) should be noted.

Color of soft parts brownish white.

Anal opening slit-like, closed above; closed part not quite twice as long as the open part. Anal about as long as the branchial, separated from it by a solid mantle-connection. Branchial opening with distinct papillæ. Palpi moderate, subtriangular, posterior margins connected for about one-third of their length.

Gills (Pl. XLVI, fig. 5*a*, *b*, *c*) rather wide, the outer one subtriangular, posteriorly slightly wider than the inner; the inner one subtrapezoidal, anteriorly wider than the outer, its anterior end immediately behind the palpi. Inner lamina of inner gill entirely connected with abdominal sac. Non-marsupial gills (Pl. XLVI, fig. 5*a*) with few, scattered interlaminar connections. The *marsupium* (Pl. XLVI, fig. 5*b*) of the females located in the inner gills, but occupying only a part, anteriorly leaving free not quite one-third of the gill, and posteriorly hardly one-fourth, so that the marsupium gravitates slightly toward the posterior section of the gill. In young females, the marsupial part (Pl. XLVI, fig. 5*b*) is much smaller, and lies distinctly behind the middle of the gill. Structure of the marsupium (Pl. XLVI, fig. 5*c* and Pl. XLVIII, fig. 2*a*, *b*) quite peculiar, consisting of *uninterrupted septa*, forming well isolated water-tubes. An interrupted or reticu-

lated arrangement of the interlaminar connections is nowhere to be seen. Nevertheless this structure must be regarded as developed out of the interrupted condition of the septa, since the non-marsupial gills distinctly show the latter (Pl. XLVI, fig. 5*c*). In consequence of the development of the water-tubes, the egg-masses fill these tubes (the ovisacs) in placenta-like bodies (conglutinated); however, these are not very solid and persistent.

Glochidium (text-figure 4*k*, p. 469) subtriangular, longer than high, rather small. L. 0.29, H. 0.23 mm. They are slightly oblique, with the lower point vertically under the posterior third of the hinge-line. They have hooks of the usual shape, about 0.09 mm. long. Immature glochidia have no hooks.

### 21. Diplodon suavidicus (Lea) (1856).

*Unio suavidicus* Lea, Obs., VI, 1857, Pl. 29, f. 24.
*Diplodon suavidicus* Simpson, 1900, p. 876; 1914, p. 1240.

*Type-locality.*—River Amazon.

*New Locality.*—Rio Tapajos, Santarem, Pará, Brazil (J. D. Haseman coll., December 6–12. 1909). Six specimens and three isolated right valves.

*Description.*—Shell small, greatest L. 28 mm., moderately solid, angularly subovate or subtrapezoidal, but little oblique, slightly narrower in front, somewhat broader and sub-pointed behind. Height 69 to 76 pr. ct. of length. Valves not gaping; dorsal margin gently curved, descending posteriorly, anteriorly descending more steeply, and passing insensibly into the anterior margin, posteriorly passing in a rather distinct (indistinct only in largest specimens) but blunt angle into the posterior margin, which descends obliquely, and is straight or very gently curved. Lower margin ascending gently in its posterior part, and meeting the posterior margin in a more or less distinct, but rounded, angle, forming the posterior point of the shell, which is a little elevated above the base-line. Anterior part of lower margin longer, sloping distinctly upward. It may be almost straight, or very gently curved, curving up into the anterior margin. Thus the anterior part of the shell appears somewhat narrower than the posterior.

Valves moderately convex, slightly flatter on the sides. Umbonal ridge rather distinct, but rounded. Posterior slope compressed, produced in young specimens into a slight wing-like elevation of the posterior angle of the upper margin. In some specimens there is a bare indication of a radial rib upon the posterior slope. Diameter 43 to 50 pr. ct. of length. Beaks not much swollen, little elevated above hinge-line, located at 22 to 29 pr. ct. of length. Beak-sculpture rather well developed, extending upon the umbonal ridge about 10 mm. or more,

but not quite so far upon the rest of the shell, and covering altogether about one-third or one-fourth of the shell. There are about fifteen or sixteen radial bars, of which the eighth and ninth unite, and between the latter there is another shorter pair, also united in v-shape. These bars are rather sharp, those just in front of the umbonal ridge are hardly broader. The most anterior bars are sometimes slightly granular, occasioned by the growth-lines cutting across them. There are generally close to the beaks a few additional radial bars upon the posterior slope, and below then some oblique, irregular wrinkles, sometimes crossing the former, so as to form v-shaped angles (forming the posterior system of re-entering angles of Lea). Lunula present, short, narrower or wider.

Epidermis with numerous, fine, concentric growth-lines, sublamellar on posterior slope, and in the larger specimens with traces of radial lines, chiefly in the front part of the shell. Color brown to blackish brown, without color-markings.

Hinge-line gently curved. Ligamental sinus over the posterior third of the laterals. Lateral teeth gently curved, thin, one in right, two in left valve. Pseudocardinals obliquely descending, rather long, compressed and thin, two in right valve, the posterior more elevated, with serrated edge. In the left valve also two pseudocardinals, the anterior larger, serrated, the posterior much smaller, sometimes rudimentary.

Cavity of shell and beaks moderate. Nacre whitish. Anterior adductor-scar moderately impressed. Anterior retractor-scar separated, and anterior protractor-scar united with adductor-scar. Posterior scars indistinct, united. Dorsal scars in beak-cavity.

MEASUREMENTS.

| No. | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|
| 1 | 18 mm. | 13 mm. = 72 pr. ct. of L. | 9 mm. = 50 pr. ct. of L. | at 4 mm. = 22 pr. ct. of L. |
| 2 | 18.5 " | 14 " = 76 " | 9 " = 49 " | 5 " = 27 " |
| 4 | 21 " | 15 " = 71 " | 9 " = 43 " | 6 " = 29 " |
| 5 | 25 " | 18 " = 72 " | 11.5 " = 46 " | 7 " = 28 " |
| 5*a* | 27 " | 18.5 " = 69 " | 12 " = 44 " | 7.5 " = 28 " |
| 6 | 28 " | 20 " = 71 " | 12 " = 43 " | 8 " = 29 " |
| Lea's figure | 21 " | 15 " = 71 " | 9.5 " = 45 " | 5 " = 24 " |

*Remarks.* My specimens are rather uniform in shape and proportions. There is some variation in the posterior part of the ventral margin, which may ascend a little more decidedly, giving to this margin a more distinct lower projection, and placing the posterior point of the shell a little higher above the base-line. In my largest specimen, all angles (upper posterior, posterior, and that of lower margin) are more rounded. The beak-sculpture may be more or less distinct and sharp, and the bars vary somewhat in length.

Previously this species was known only from a single individual described by Lea. There is not the slightest doubt that my specimens belong here, and one of them (No. 4) is almost a replica of that of Lea. Lea believes that his shell is a young one, and it certainly is not full-grown, but, as my material shows, this species does not grow very much larger. Von Ihering (1893, p. 120) suggests that this might be the young stage of *U. wheatleyanus* Lea, but this cannot be the case, since the latter has a different, much heavier beak-sculpture.

I am uncertain about the systematic position of this species, but there are certain resemblances in the shape of the shell to that of the *lacteolus*-group. This species is also interesting because of the fact that it is one of the few forms of *Diplodon* found in the Amazon-drainage.

### 6. Group of *Diplodon ellipticus*.

Shell more or less elongated, but often rather high and short; subovate or subtrapezoidal, distinctly oblique at all stages of growth, with the longest axis forming an angle with the line of the ligament. Anterior end narrower, posterior end higher, and lower margin distinctly ascending in its anterior portion. Beak-sculpture fine or coarse, more or less developed.

The chief character of this group is the *obliquity* of the shell, brought about by a widening of the posterior portion of the shell in the vertical direction, so that the posterior end lies rather low, and the longest dimension is not parallel or nearly parallel to the ligament, but forms a distinct angle with it. Although an obliquity is sometimes indicated in the species of the previous groups, it generally disappears with increasing age, while in the present group the obliquity is rather emphasized in older shells. It is all-important, in order to correctly judge as to the shape of these shells, to place them in a uniform position, always with the ligament running horizontally.

The outline of the shells of this group varies a good deal, and some of them become very high in proportion to length, so that the outline appears more nearly subrotund, similar to the shape in the subgenus *Cyclomya*. However, in the latter the greatest height of the shell is always situated more nearly in the middle under the middle of the ligament, while in the shells of the *ellipticus*-group the greatest height is more posteriorly, at the posterior end of the ligament, or even beyond that.

### 22. Diplodon ellipticus Spix (1827).

*Diplodon ellypticum* (error typogr.) Spix, 1827, Pl. 26, fig. 1–2.

*Unio ellipticus* Wagner, 1827, p. 33; Von Ihering, 1890, p. 163, Pl. 9, figs. 8–9; Von Ihering, 1893, p. 108.

*Diplodon wagnerianum* SIMPSON, 1900, p. 877; 1914, p. 1246.

*Type-locality.* Rio San Francisco (Wagner).

*Other Localities.*—Rio Parahyba do Sul, Rio de Janeiro (Von Ihering, 1893, p. 115); Rio Santa Maria, Espirito Santo (Von Ihering, 1910, p. 134) (drainage of Rio Doce). The form from the latter locality has been named var. *santanus* Von Ihering.

Rio Piracicaba, São Paulo, and Rio Tamanduatahy, São Paulo (Von Ihering). The latter two localities are somewhat doubtful, since the specimens are not exactly like *ellipticus*. The location and drainage of the last named river is unknown to me.

In the Carnegie Museum is one specimen, labeled "Brazil" (Holland Collection). Not quite typical.

The change of the specific name *ellipticus* to *wagnerianus* is unwarranted. Spix gave the name in the plate in connection with the generic name *Diplodon.* Since the latter stands, the specific name also is entitled to recognition.

In spite of Von Ihering's re-description of the type, this species is as yet poorly known, and our knowledge of it is founded chiefly upon what Von Ihering has said. The species is positively known from the Rio San Francisco and the Rio Parahyba do Sul; the other localities are more or less doubtful, since the specimens described from them do not fully agree with the type. Those from the Rio Santa Maria have been distinguished as a variety.

All we can gather from descriptions and figures is that *D. ellipticus* is a subelliptical or subtrapezoidal shell, of dark green to blackish color, with rather smooth surface. It has in the anterior part of the shell a shallow depression, often producing a shallow emargination in the anterior part of the ventral margin. In outline, the shell is distinctly oblique, narrower in front, higher behind. The beak-sculpture consists of simple, fine radial bars, which are rather short, and somewhat cut up on the posterior slope by irregular, oblique wrinkles. The nacre is blueish white. Pseudocardinals somewhat compressed, but not thin, crenulated, two in right, one in left valve, but the latter with an angle at its base, representing the remnant of a posterior tooth.

Our specimen from Brazil was received as *ellipticus.* It agrees in most of the above characters, except that it is shorter in proportion to height, with less pointed posterior end. Also the projection of the lower margin is indistinct. The beak has eleven radial bars in front of the posterior ridge, the seventh and eighth meeting in the middle. On the posterior slope there are corrugations and fine, oblique ridges. L. 32 mm.; H. 21 mm.; D. 12 mm. This specimen might very well be

a young *ellipticus*, and may correspond to the var. *santanus* of Von Ihering (smaller, projection of lower margin less distinct).

### 23. Diplodon berthæ Ortmann, sp. nov.

*Shells:* Plate XXXVIII, figs. 1, 2, 3, 4; *Anatomy of gills:* Plate XLVI, fig. 6.

*Type-locality.*—Rio Jacuhy, Cachoeira, Rio Grande do Sul, Brazil (J. D. Haseman coll., January 26, 1909). *Type-set:* Carn. Mus. Cat. No. 61.5865. Sixteen specimens, all with soft parts, including males, barren and gravid females. (There were twenty-three specimens in the original lot).

*Additional Locality.*—Rio Vaccahy Mirim, Santa Maria, Rio Grande do Sul, Brazil (J. D. Haseman coll., January 29. 1909). One male with soft parts.

*Distribution:* Guahyba drainage in southern Brazil.

*Description of Shell.*—Shell rather small, maximum length 65 mm.; rather solid, chiefly so anteriorly, and in old shells often much thickened along the lower anterior margin. Outline subovate to subtrapezoidal, distinctly oblique, broad and rounded, or somewhat pointed behind. Height from 55 to 67 pr. ct. of length. Valves not gaping. Dorsal margin straight, or gently descending posteriorly, forming a more or less distinct obtuse angle with the posterior margin. The latter obliquely descending, gently convex, and curving around into the posterior part of the lower margin, forming with the latter in young specimens an indistinct rounded angle, which, however, may become more distinct in old specimens. Lower margin in normal specimens with a distinct rounded projection, forming the lowest point of this margin, situated far back, behind the posterior end of the ligament. From this point the lower margin curves up behind to the posterior end of the shell and this part is quite short. Anteriorly the lower margin also slopes upward, and is almost straight for a considerable distance; sometimes it is even slightly concave; then it curves up into the anterior margin. Thus the shell appears considerably narrower anteriorly, broader (higher) posteriorly, with the greatest height situated far backward.

Valves moderately and not uniformly convex. The greatest convexity is near the anterior end and over the posterior ridge, which is broad and not sharply marked. In front of the posterior ridge the sides of the disk are distinctly and broadly flattened, and sometimes even slightly concave, producing the emargination of the anterior part of the lower margin. Posterior slope somewhat compressed, very rarely with a slight trace of a rib or a furrow. Greatest diameter of the shell 32 to 43 pr. ct. of the length, located well behind, upon, or close in front of, the posterior ridge. Thus, although rather swollen in the region of the posterior ridge,

the shell appears in front of it rather more compressed. Beaks not much swollen, and not very prominent, located at from 23 to 29 pr. ct. of the length. Beak-sculpture consists of twelve to fourteen radial bars, which are sharp and rather distant from each other, the ninth, tenth, and eleventh (immediately in front of and upon the posterior ridge) are longest, about 10 to 12 mm. long; the seventh and eighth may consist of two bars united in V-shape, but this cannot be seen clearly, since in all specimens the tips of the beaks are eroded. These median bars (seventh and eighth) are also slightly shorter than those in front, and distinctly shorter than those behind them; the last two or three bars are fine and somewhat shorter, and stand upon the posterior slope, becoming indistinct. In a few of my specimens there are traces of oblique wrinkles upon the posterior slope. Lunula short and narrow, distinct only in larger specimens.

Epidermis smooth, rather shining, with numerous, closely set, fine, concentric lines, and stronger and irregular concentric wrinkles. The fine lines become sub-lamellar on the posterior slope and towards the margins. A fine radial sculpture is present, chiefly in the anterior part of the shell, but it is not very evident. Color greenish black to brownish black, darkest in old shells. Young shells are more distinctly greenish, dark olive-green, shading towards the beaks to gray-green and brownish olive. There are no distinct color-bands and no distinct color-rays, except in very young specimens, where there are traces of dark green rays on the posterior slope, seen when held up against a strong light.

Hinge straight or gently curved. Ligamental sinus over the posterior third or fourth of the laterals (more posteriorly in old shells). Lateral teeth curved, more strongly so in their posterior part in old shells, one in right, two in left valve, edges rugose. Pseudocardinals two in right, one in left valve, subcompressed, not very long, in old specimens sometimes almost stumpy. The posterior pseudo-cardinal of right valve stronger and more elevated than the anterior, often much divided, and always much crenulated. Very often there is a second posterior small pseudocardinal in the left valve.

Cavity of shell and beaks shallow. Nacre whitish, in old specimens often very thick anteriorly, and with pinkish tints; posteriorly very iridescent. Adductor-scars deeply impressed anteriorly, less so posteriorly. Anterior retractor-scar small and deep, separated from the adductor-scar; anterior protractor-scar united with it. Posterior retractor-scar connected with adductor-scar. Pallial line distinct. Dorsal scars in an oblique irregular row in the beak-cavity.

*Remarks.*—This species may be what Von Ihering (1893, p. 102) calls *æthiops* in the Guahyba drainage, but only the remark (p. 104) that this *æthiops* has a

broad, shallow furrow in the anterior part of the shell, seems to confirm this assumption. In other respects it is impossible to decide, whether this is, or is not, the *æthiops* of Von Ihering. It surely is *not* the *æthiops* of Lea. Of the few other species incidentally mentioned by Von Ihering as found in the Guahyba-drainage, none can be compared with our species. Its chief characters are the subovate to subtrapezoidal distinctly oblique shape, narrow in front, broader behind, and the peculiar compression of the shell in the anterior part. The beak-sculpture and color of the epidermis are also characteristic.

MEASUREMENTS.

| No. | Sex. | Length. | Height. | Diameter. | Beaks. | Figured. |
|---|---|---|---|---|---|---|
| | *Type-set* | | | | | |
| 3... | ♂ | 31.5 mm. | 21 mm. =67 pr. ct. of L. | 10 mm. =32 pr. ct. of L. | at 8 mm. =25 pr. ct. of L. | Pl. XXXVIII, fig. 2. |
| 11... | ♂ | 43.5 " | 27.5 " =63 " | 18 " =41 " | 12.5 " =29 " | |
| 14... | ♀ | 47 " | 31.5 " =67 " | 19 " =40 " | 12.5 " =27 " | |
| 22... | ♀ | 51.5 " | 32 " =62 " | 22 " =43 " | 12 " =23 " | |
| 23... | ♀ | 52 " | 29 " =56 " | 21.5 " =41 " | 12 " =23 " | |
| 24... | ♂ | 56 " | 36 " =64 " | 21.5 " =38 " | 13.5 " =24 " | Pl. XXXVIII, fig. 1. |
| 34... | ♂ | 65 " | 35.5 " =55 " | 26 " =40 " | 15 " =23 " | (Santa Maria) |

I cannot compare this species with any other, except *D. ellipticus* Spix. The general shape is very much the same, but *ellipticus* seems to be more elongate (height only 54 pr. ct. of length). The posterior end is slightly more pointed, and the diameter is distinctly less (31 pr. ct. on the average). In our species the average height is 62 pr. ct. and the diameter 39 pr. ct. In addition our shell seems to be thicker and more solid, chiefly in old specimens, where the lower anterior margin is considerably and strikingly thickened, a character not mentioned in *ellipticus*.

Old shells often become freakish, assuming irregular shapes. Frequently the posterior part of the shell grows more strongly in length, thus rendering the shell exceptionally long (as in No. 23). In such specimens the projection of the lower margin is obscured, and the posterior point of the shell is very little elevated above the base-line. Furthermore the shell in general is more pointed behind. Such specimens also appear more swollen. However, the growth-lines clearly indicate that, when young, these individuals had the normal shape. In other old shells the whole posterior part is more developed (No. 24, Pl. XXXVIII, fig. 1*a*) and is deflected downward. This fact tends to preserve the general shape, but renders the anterior part of the lower margin somewhat concave.

*Anatomy.*—Judging from the soft parts at hand, twelve specimens are males, five are barren females, and seven are gravid females. Only one of the latter contained immature glochidia. The date of collection (January 26) apparently is near the beginning of the breeding season.

*Color.*—Distal part of foot dark brownish, grayish, or blackish; the rest of the soft parts are whitish.

Anal opening closed above; the closed part about four times as long, or a little longer than the open part; the latter slit-like, slightly shorter than the branchial opening. The latter with small, but distinct papillæ, separated from the anal by a solid mantle-union. Palpi subtriangular, moderately large, of the usual shape; their posterior margins connected at base.

Gills rather long and wide. Outer gill subtriangular, widest at the beginning of the posterior third, and here it projects a little beyond the inner gill. Inner gill subtrapezoidal, its anterior end immediately behind the palpi. Inner lamina of inner gill connected with abdominal sac.

Structure of non-marsupial gills as usual. In the female, the *marsupium* (Pl. XLVI, fig. 6) is located in the inner gill, and in large specimens it is restricted to the middle part of the gill, leaving non-marsupial almost one-third at the anterior end, and a somewhat smaller portion at the posterior end. In young specimens the marsupium is smaller. When charged, the marsupium forms a slightly swollen, lenticular, rounded, or oblong patch in the middle of the gill, most of it lying behind the middle. The interlaminar connections of the marsupium are strongly developed, forming very incomplete, interrupted septa, and arranging themselves rather in transverse and oblique rows, so that the vertical septiform structure is obscure, while a reticulate and irregularly quincuncial arrangement prevails. Only near the margin of the gill is a septiform structure indistinctly indicated. The egg-masses do not conglutinate into placentæ-like structures.

Only one of my females has very young *glochidia*. They are, as far as can be seen, of the usual shape, subtriangular, and somewhat oblique. Exact measurements could not be obtained. No hooks are visible, but, of course, such may be present in ripe glochidia.

### 24. Diplodon enno Ortmann, sp. nov.

*Shells:* Plate XXXVIII, figs. 5, 6, 7, 8; *Anatomy of gills:* Plate XLVI, fig. 7.

*Type-locality.*—Rio Grande, Boqueirão, Bahia, Brazil (S. Francisco drainage). (J. D. Haseman coll., January 9, 1908). *Type-set:* Carn. Mus. Cat. No. 31.9264. Eighteen specimens, males and barren females, with soft parts. (A number of additional young specimens were in the original set.)

According to the latest census of the *Naiades* from the Rio S. Francisco drainage (Von Ihering, 1910, p. 138), there are only two species of *Diplodon* present in this system: *D. rotundus* Spix, and *D. ellipticus* Spix. The former is much

higher and much more rounded than the present species; the latter is more elongated and more pointed behind, and has, besides, a smooth epidermis (*Cf.* Von Ihering, 1890, p. 163). Since it is impossible for me to find any other South American species of *Diplodon*, the description of which answers to the present species, we must regard the latter as new.

*Description of Shell.*—Shell small to medium (maximum length 53 mm.), rather thin. Outline subovate or subtrapezoidal, distinctly oblique, higher behind, narrowed anteriorly, the obliquity being most pronounced in older specimens. Height 56 to 75 pr. ct. of length (against 54 pr. ct. in *ellipticus*, and 86 or 87 pr. ct. in *rotundus*). Valves not gaping. Dorsal margin straight or gently convex, forming a rather distinct or obtuse angle with the posterior margin, which descends obliquely and rather steeply, is nearly straight or gently convex, and curves into the lower margin without forming a distinct posterior point. The posterior extremity of the shell is located relatively low and is only moderately elevated above the base-line. Lower margin with its lowest point located rather posteriorly, vertically below the posterior end of the ligament, or even behind it, strongly ascending in a curve toward the posterior end of the shell, but nearly straight or very slightly convex in its anterior part, and sloping upward toward the anterior margin, so that the anterior portion of the shell is distinctly narrower than the posterior, producing thus the oblique appearance of the whole shell.

Valves comparatively compressed. Diameter 28 to 45 pr. ct. of length. Greatest convexity and greatest diameter situated well back upon the posterior ridge, which, however, is very indistinct and broad. Sides of the shell in front of posterior ridge not very convex and rather flattened. Posterior slope compressed, sometimes with a faint trace of a radial groove, somewhat elevated (wing-like) toward the upper posterior angle. Beaks not swollen, and hardly elevated above the hinge-line, located at from 22 to 28 pr. ct. of the length. Beak-sculpture sharp and fine, distinct, but restricted to the region near the beaks. There are fifteen to eighteen radial bars, the ninth and tenth in the middle, joined and v-shaped at their lower ends. The longest bars (6 to 8 mm.) stand upon the posterior ridge, the anterior ones being distinctly shorter. There are a few anterior bars and upon the posterior slope a few posterior bars, and sometimes traces of oblique wrinkles. None of the bars are distinctly granular, and a comparatively slight degree of erosion obliterates all traces of beak-sculpture. Lunula indistinct and narrow, visible only in older shells.

Epidermis not shining, but rather rough. This is due to a great number of fine, irregular, concentric lines, which, when well-preserved, are lamellar and

elevated, showing this character all over the disk, being, however, more distinctly lamellar and more crowded upon the posterior slope and near the margins. Even when these fine lamellæ are worn off, the epidermis does not become shining, but remains dull, and when well-preserved, the epidermis appears cloth-like. There are no traces of radial sculpture. Color of epidermis dark greenish black, but often in the middle of the disk and towards the beaks brownish black. The greenish tint is not very evident, and is best seen in young specimens.

Hinge-line very gently curved. Ligamental sinus over the posterior third of the laterals. Lateral teeth curved, one in right, two in left valve, their edges slightly corrugated or nearly smooth. Pseudocardinals narrow and compressed, but not very long, corrugated and rugose, but not cut up, two well developed pseudocardinals of nearly equal size in right valve, one well-developed in left valve; but there often is a smaller posterior one in the left valve, and another small, low, and narrow anterior one, so that the left valve may have three pseudocardinals. The middle one, however, is always the largest. Sometimes the posterior pseudocardinal of the right valve is higher and thicker than the anterior.

Cavity of shell and beaks shallow. Nacre blueish silvery, very iridescent, and sometimes discolored yellowish. Anterior adductor-scar distinct and moderately impressed. Anterior retractor-scar rounded, small and rather deep, separated from adductor-scar. Anterior protractor-scar united with it. Posterior adductor-scar rather indistinct and not impressed, the posterior retractor-scar forming an upper process of it. Pallial line not very sharp. Dorsal scars few in beak-cavity.

MEASUREMENTS.

| No. | Sex. | Length. | Height. | Diameter. | Beaks. | Figured. |
|---|---|---|---|---|---|---|
| 18... | ? | 12.5 mm. | 7 mm. =56 pr. ct. of L. | 3.5 mm. =28 pr. ct. of L. | at 3.5 mm. =28 pr. ct. of L. | |
| 14... | ? | 22 " | 13.5 " =61 " | 7 " =32 " | 6 " =27 " | |
| 8... | ♂ | 28 " | 20.5 " =73 " | 9 " =32 " | 7 " =25 " | |
| 4... | ♂ | 35 " | 26 " =74 " | 12 " =34 " | 8 " =23 " | Pl. XXXVIII, fig. 5. |
| 2... | ♀ | 45 " | 32 " =71 " | 16.5 " =37 " | 10 " =22 " | Pl. XXXVIII, fig. 8. |
| 1... | ♀ | 53 " | 40 " =75 " | 24 " =45 " | 12.5 " =24 " | Pl. XXXVIII, fig. 7. |

*Remarks.*—The dimensions of this species change slightly with age, in that younger shells are not so high in proportion, and consequently, they appear less distinctly oblique than older ones. The diameter of young shells is also less than in old ones, and the highest figures (37 to 45 pr. ct.) are shown by old females. In other respects my specimens are rather uniform, and the oblique, not very elongated shape, and the dull, blackish epidermis and silvery nacre are chiefly characteristic.

*Anatomy.*—It was not possible to positively ascertain the sex of my smallest specimens. But, I have other specimens, of which five are positively males, and seven of which are females. None of the latter were gravid.

Color of soft parts whitish, distal part of foot brown.

Anal opening closed above; closed part considerably longer than the open part; the latter slit-like, shorter than the branchial opening, and separated from it by a solid mantle-connection. Branchial opening with distinct papillæ. Palpi subtriangular, their posterior margins connected for about one-third of their length.

Gills of the usual shape, rather wide, the inner anteriorly wider, its anterior end close to the palpi. Inner lamina of inner gill entirely connected with abdominal sac. Non-marsupial gills of the usual structure, with few and scattered interlaminar connections. *Marsupium* of the female (Pl. XLVI, fig. 7*b*) located in the inner gill, occupying nearly half of it in the middle, leaving non-marsupial one-fourth of the gill both at the anterior and posterior end. In young females the marsupial part is smaller (Pl. XLVI, fig. 7*a*), but also located nearly centrally. Interlaminar connections of the marsupium reticulated or quincuncial toward the base, but forming interrupted septa toward the margin.

### 25. Diplodon gratus (Lea) (1860).

*Section of gills:* Plate XLVIII, fig. 3.

*Unio gratus* Lea, Obs., X, 1863, Pl. 43, fig. 290; Sowerby, XVI, 1868, Pl. 84, fig. 444.
*Diplodon* (*Cyclomya*) *gratus* Simpson, 1900, p. 886.
*Diplodon* (*Cyclomya*) *fontainianus gratus* Simpson, 1914, p. 1281.

*Type-locality.*—Rio Uruguay.

*New Locality.*—Rio Uruguay (in mud), Uruguayana, Rio Grande do Sul, Brazil (J. D. Haseman coll., February 5, 1909) twenty-one specimens, males and females, all with soft parts.

*Distribution.*—Positively known only from the Uruguay River. Von Ihering (1893, p. 92) gives this form also from Rio Guahyba, Porto Alegre, Rio Grande do Sul. However, as we shall see, this is not the typical *gratus*, and the Guahyba-form has already been distinguished by Simpson as var. *deceptus* (see below).

*Description of Shell.*—Rather small, maximum length of my specimens 53 mm., moderately thick. Outline obliquely subrotund, subovate, or subtrapezoidal, very variable, more or less high (height 72 to 85 pr. ct. of length). There is an indistinct relation of the shape to sex, in so far that the highest shells (79 pr. ct. and over in height) are all males, while the more elongated specimens may be either

males or females, the former being more subrotund, the latter more subovate-subtrapezoidal. Dorsal margin gently convex, forming a more or less distinct, obtuse angle with the posterior margin, the latter obliquely descending, straight, or gently curved, curving broadly around into the lower margin, forming the indistinctly defined, rounded, posterior end of the shell. Lower margin ascending in its anterior part, gently curved in the higher shells, or almost straight in those more elongated, its posterior part curving up towards the posterior margin. The lowest point of the lower margin (and greatest height of shell) is located well backward, vertically below the posterior end of the ligament, or even behind this. Thus the shell presents a rather oblique shape, being narrowed anteriorly, and higher posteriorly, but, according to the varying height, this obliquity is more or less pronounced, most distinctly in the more elongated shells, less so in those more elevated, where the outline approaches the subrotund shape.

Valves moderately but variably convex, convexity greatest upon the broad posterior ridge, smallest upon the sides of the disk, where elongated specimens are almost flat. Posterior slope slightly compressed, sometimes with a trace of a radial furrow and a ridge, which, however, may be entirely obliterated. Diameter 36 to 50 pr. ct. of length. The more compressed specimens are the smaller, but no distinct relation to sex can be discovered in this. Beaks moderately swollen, not very prominent, located at 25 to 34 pr. ct. of the length (more anteriorly in larger specimens). Beak-sculpture weakly developed, seen only in smaller specimens, consisting of twelve to thirteen radial bars, of which the seventh and eighth unite v-shapedly. The bars do not differ much in length, although the posterior ones are slightly longer, the maximum being hardly over 8 mm. long. They are not very sharp, but rather blunt, only the most anterior and posterior (upon posterior slope) are somewhat finer and sharper. Often there are upon the posterior slope irregular oblique wrinkles, which may be rather numerous, or may be altogether absent. Lunula absent in young, but sometimes seen in older specimens, short and very narrow.

Epidermis smooth in the middle of the disk, but not very shining, covered with numerous somewhat irregular, fine, concentric lines, and more widely separated irregular concentric wrinkles. The concentric lines are sublamellar upon the anterior end, the posterior slope, and towards the margin, and sometimes they are sublamellar all over the disk, but the latter is the case only in young individuals. In old specimens they undoubtedly have been worn off. Radial sculpture generally present. It may be very obscure, chiefly in younger shells, but is visible in older shells, consisting of faint, blunt radial ridges, which are rather irregular, often in-

terrupted, and more distinct in the anterior part of the shell. Even when best developed, they do not constitute a prominent feature of the surface. Color of epidermis dark olive-green to blackish. In young specimens it is more grayish or brownish green towards the beaks; in older specimens it appears nearly black. When slightly worn, it is in places lighter, brownish olive, or greenish olive. In some older specimens brownish tints appear towards the lower margin, and sometimes a faint brownish concentric band is indicated. The general impression of the color of the epidermis, however, is blackish green, not brown. No color-rays are visible.

Hinge-line gently curved. Ligamental sinus over the posterior third of the laterals, in young specimens over the posterior half. Lateral teeth curved more strongly in their posterior part in old shells, one in right, two in left valve, their edges rough. Pseudocardinals directed obliquely forwards and downwards, lamellar and compressed, but not very long. In the right valve there are two of them, the posterior much larger than the anterior. In the left valve there is one pseudocardinal, but quite often a smaller posterior one is present. All pseudocardinals are rough, crenulated, or serrated.

Cavity of shell and beaks moderate. Nacre whitish, iridescent, in young shells blueish or greenish silvery towards the edges. In older shells it becomes more opaque white, and assumes generally a creamy or salmon hue in and near the cavity. In a few specimens there is a very delicate pinkish tint all over the nacre.

Anterior adductor-scar rather deep, subelliptical; anterior retractor-scar small, deep, isolated from the adductor-scar; anterior protractor-scar connected with it. Posterior adductor-scar subtriangular, faintly impressed, posterior retractor-scar forming an upper triangular process of it. Pallial line distinct. Dorsal scars few, in an irregular, oblique line in the beak-cavity.

MEASUREMENTS.

| No. | Sex. | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|---|
| *b*... | ? | 23.5 mm. | 17 mm. = 72 pr. ct. of L. | 8.5 mm. = 36 pr. ct. of L. | at 7.5 mm. = 32 pr. ct. of L. |
| 2... | ? | 28.5 " | 23.5 " = 85 " | 11 " = 39 " | 9 " = 32 " |
| 3... | ? | 32 " | 23.5 " = 73 " | 14 " = 44 " | 11 " = 34 " |
| 7... | ♀ | 36 " | 26 " = 72 " | 13.5 " = 38 " | 11 " = 31 " |
| 13... | ♂ | 37.5 " | 32 " = 85 " | 16.5 " = 44 " | 10 " = 27 " |
| 10... | ♂ | 39 " | 29 " = 74 " | 16 " = 41 " | 11.5 " = 29 " |
| 16... | ♂ | 40 " | 32.5 " = 81 " | 20 " = 50 " | 11.5 " = 29 " |
| 14... | ♀ | 41 " | 32 " = 78 " | 18 " = 44 " | 12.5 " = 30 " |
| 22... | ♂ | 47 " | 39.5 " = 84 " | 20 " = 43 " | 12 " = 26 " |
| 21... | ♀ | 50 " | 36 " = 72 " | 21 " = 42 " | 14 " = 28 " |
| Half shell.. | | 53 " | 38 " = 72 " | 22 " = 42 " | 13 " = 25 " |

*Remarks.*—According to Simpson (1914), this form (*gratus*) is a variety of *D. fontainianus* (D'Orbigny), and there is no doubt that both are closely allied to each other. However, Simpson erroneously gives the distribution of *fontainianus* as: "Uruguay River and its affluents; Paraná River, southern Brazil," while it is known only, according to D'Orbigny and Von Ihering (1893) from the Rio Parahyba, Rio de Janeiro, the upper Paraná-drainage in São Paulo, and Lagoa Santa in Minas Geraes (Rio de las Velhas, São Francisco-drainage). In 1910 (p. 138) Von Ihering drops this latter locality. *Fontainianus* has never been reported from the Uruguay. Thus it is not very likely that my specimens from this river are *D. fontainianus,* although they agree with it in some particulars.

According to Von Ihering's account of *D. fontainianus* (1893, p. 90, Pl. 4, fig. 6), the latter differs from my specimens chiefly in having the posterior retractor-scar separated from the adductor-scar, but otherwise they are very similar. This holds good chiefly in the color of the epidermis. My specimens are greenish black, which agrees best with Von Ihering's *D. fontainianus,* which is "black, with greenish basis," and to a degree with D'Orbigny's "brun noirâtre," while Lea describes his *gratus* as "dark olive brown." The differences between *D. gratus* and *D. fontainianus,* as given by Simpson, concern the shape of the shell, which is said in *gratus* to be more wedge-shaped in front, and the texture of the epidermis, which is said to be smoother, subshining, and lighter in color. These differences I cannot recognize in my specimens. It is therefore hard to decide by which name they should be called. However, my specimens coming from the Uruguay River, being practically topotypes of *gratus,* I have concluded to call by this name, and, in order to avoid any misunderstanding, I have given a full description of them.

Von Ihering (1893) believes that he has discovered sexual differences in the shell of *D. fontainianus,* the males being higher and shorter, and more rounded, the females being longer and more subtrapezoidal. Similar differences in shape are also noticed in our *D. gratus.* I have seventeen specimens in which the sex has been positively ascertained by examination of the gills, and I find that it is not possible to accurately determine the sex according to the shape of the shell. First of all, the two shapes are not sharply separated, but pass insensibly into each other, many specimens being intermediate between the two extremes. Besides, if form has any relation to sex, we may say that the highest shells (with the height of 79 pr. ct. of length and over) are, indeed, males; but among the others, having the height of 72 to 78 pr. ct. of length, there are as many females as males, and this applies both to larger and smaller shells. It is true, that the average height of all my males is about 78 pr. ct., and the average height of all my females is 75 pr. ct.; but

these differences are so slight, that they do not furnish an exact criterion for the distinction of the sexes.

*Anatomy*[20].—The soft parts of eleven males and six females have been investigated.

Color of distal part of foot blackish, this color sharply set off from the pale basal part. Rest of soft parts whitish. Outer edge of anal opening (including the closed part) and of branchial, black; this color running forward beyond the branchial opening for a short distance.

Anal opening closed above; closed part much longer than the open, the latter slit-like, a little shorter than the branchial opening, and separated from it by a solid mantle-connection. Branchial opening with small, but distinct papillæ. Palpi rather large for the size of the species, subtriangular, with curved lower margin; posterior margins connected only at base.

Gills moderately long and rather wide. Outer gill with strongly convex lower edge, its widest part a little back of the middle, and about as wide as the inner gill in its posterior part. Anteriorly it becomes narrower, and its anterior end is near the highest point of the mantle-attachment-line. Inner gill with the inner lamina entirely connected with abdominal sac, its edge nearly straight in the anterior part, where it is much wider than the outer gill. Anteriorly it is slightly narrowed, and its anterior end is immediately behind the palpi. Structure of non-marsupial gills (Pl. XLVIII, fig. 3*a*) somewhat unusual, with rather crowded, irregular interlaminar connections, forming weak, interrupted septa; these connections are more frequent toward the margins of the gills. Inner gill of the female *marsupial*. Its interlaminar connections (Pl. XLVIII, fig. 3*b*) are more crowded, and heavier, arranged in interrupted rows running parallel to the gill-filaments, forming incomplete septa. The marsupium occupies only a part of the gill, leaving a small section at the anterior end free, a somewhat larger one (but hardly one-fourth) at the posterior end free also, so that the marsupium is located in the middle of the gill, and slightly more anteriorly than posteriorly.

In this species, the structure of the marsupial and non-marsupial gills is more alike than usual as regards the arrangement and frequency of the interlaminar connections, but in the marsupium the connections are decidedly heavier and stronger, and form more distinct, although interrupted, septa (See Pl. XLVIII, figs. 3*a* and 3*b*).

[20] The anatomy of *D. fontainianus* has been discussed by Von Ihering (1893, p. 90), but the finer structure of the marsupium has not been described. The glochidia are said to be subtriangular, without hooks. Their length is 0.4 to 0.5 mm. Thus they are unusually large for the genus, and belong to the largest known among all *Naiades*.

26. Diplodon deceptus (Simpson) (1914)

*Shells:* Plate XXXIX, figs. 1, 2, 3, 4, 5; *Anatomy of gills:* Plate XLVII, fig. 1; *Section of gills:* Plate XLVIII, fig. 4.

*Unio gratus* Von Ihering (*non* Lea), 1893, p. 92.

*Diplodon* (*Cyclomya*) *fontainianus deceptus* Simpson, 1914, p. 1281.

*Type-locality.*—Guahyba, Brazil.

*Other Locality.*—Rio Guahyba, Porto Alegre, Rio Grande do Sul, Brazil (Von Ihering).

*Localities Represented in Carnegie Museum.*—Rio Guahyba, Porto Alegre, Rio Grande do Sul, Brazil (J. D. Haseman coll., January 24, 1909) two shells and one right valve (*Topotypes*). Rio Jacuhy, Cachoeira, Rio Grande do Sul, Brazil (J. D. Haseman coll., January 26, 1909) ten specimens with soft parts, males and females.

*Distribution.*—Drainage of the Rio Guahyba and its tributary, the Rio Jacuhy, in Rio Grande do Sul.

There is no question that my specimens belong to the form called by Von Ihering *gratus*, and by Simpson *deceptus*. Von Ihering compares his *D. gratus* with *D. fontainianus*, and says that the former much resembles the latter in shape, but that the epidermis of *D. gratus* is brown, shows radial sculpture, and is smoother; that the beaks are more anterior (24 to 31 pr. ct., average 27 pr. ct., against 29 to 39 pr. ct., average 34 pr. ct. in *D. fontainianus*); that the pseudocardinals of *D. gratus* are shorter and more stumpy; and that the posterior retractor-scar is always connected with the adductor-scar.

All these characters hold good for my specimens, and they distinguish this form also from the real *D. gratus* of the Uruguay River, except that the location of the beaks does not differ so much (in true *D. gratus* it is 25 to 34 pr. ct.).

Simpson's *D. deceptus* has been described as being unevenly obovate, subinflated, rather solid; pseudocardinals shorter, more stumpy, and much split. This also fits the present form, and I have no doubt that *D. deceptus* is the same shell as that called *D. gratus* by Von Ihering.

The chief differences between *D. deceptus* and *D. gratus* are the following:

1. *D. deceptus* has a greater tendency toward the obliquely elongated shape, with subtrapezoidal or subovate outline. The height varies from 65 to 78 pr. ct. of the length, while in *D. gratus* it ranges from 72 to 85 pr. ct.

2. The epidermis of *D. deceptus* is always brownish, with hardly any green in it, and not blackish green. It is smoother, since the fine concentric lines are not

lamellarly elevated (except indistinctly so near the margins), and the radial sculpture is more distinct, consisting of faint furrows, becoming often subscalariform toward the margins.

3. The pseudocardinals of *D. deceptus* are more stumpy, chiefly in larger specimens. In younger ones this difference is not so marked, yet noticeable, when individuals of the same size are compared. In large specimens they are short and thick, chiefly so the posterior one of the right valve, and the anterior of the left (Pl. XXXIX, figs. 1*c*, 1*d*). The posterior one of the left valve generally is well developed, although smaller than the anterior one. All these teeth are split up into a number of denticles, and there are frequently accessory teeth, anteriorly in the left, and posteriorly in the right valve.

All other characters are as in *D. gratus*, but *D. deceptus* grows to a larger size.

MEASUREMENTS.

| No. | Sex. | Length. | Height. | Diameter. | Beaks. | Figured. |
|---|---|---|---|---|---|---|
| Cachoeira | | | | | | |
| 1... | ? | 28 mm. | 19 mm. =68 pr. ct. of L. | 9 mm. =32 pr. ct. of L. | at 8 mm. =29 pr. ct. of L. | |
| 4... | ♂ | 43 " | 33 " =77 " | 18.5 " =43 " | 13 " =30 " | Pl. XXXIX, fig. 3. |
| 6... | ♀ | 47.5 " | 35 " =74 " | 19 " =40 " | 15 " =31 " | Pl. XXXIX, fig. 4. |
| 8... | ♂ | 56 " | 39.5 " =71 " | 22.5 " =40 " | 14 " =25 " | |
| 11... | ♂ | 62 " | 40 " =65 " | 27.5 " =44 " | 17 " =27 " | Pl. XXXIX, fig. 2. |
| 9... | ♀ | 64 " | 43 " =67 " | 26 " =41 " | 17 " =27 " | |
| Porto Alegre | | | | | | |
| 2... | | 49 " | 37 " =76 " | 18.5 " =38 " | 12 " =24 " | |
| 4... | | 55 " | 43 " =78 " | 26 " =47 " | 13 " =24 " | |

*Remarks.*—In this species we also observe higher and more elongated shells, nevertheless no relation between shape and sex is apparent. In fact, the most elongated specimen No. 11, H. 65 pr. ct. (See Pl. XXXIX, fig. 2) is a male, and not, as might be expected (according to Von Ihering) a female. Altogether the number of individuals with the sex positively known is rather small, but the gradual transition of the more elongated into the shorter and higher ones is evident.

*Anatomy.*—From Cachoeira, I have the soft parts of three young specimens, of which the sex is not determined, and five males, and four barren females.

*Color* of the distal part of the foot dark gray, this color sharply marked off from the whitish basal part. The rest of the soft parts whitish.

Anal opening closed above; the closed part about four times as long as the open, which is slit-like, shorter (about three-fourths) than the branchial opening, and separated from the latter by a solid mantle-connection. Branchial opening short, with small, but distinct, papillæ. Palpi rather large, subtriangular, lower margins strongly convex, posterior margins with a short connection at base.

Gills long and wide, posteriorly of about the same width, but anteriorly the inner is wider. Outer gill with margin curved, much narrower anteriorly, its anterior end near the highest point of the mantle-attachment-line. Margin of inner gill nearly straight in the middle, anteriorly this gill is a little narrowed, its anterior end immediately behind the palpi. Inner lamina of inner gill entirely connected with abdominal sac.

Non-marsupial gills with scattered, short, interrupted interlaminar connections, elongated in the direction of the gill-filaments. The *marsupium* of the female (pl. XLVII, fig. 1) is in the inner gill, leaving free a small anterior and posterior section, about one-fourth in front, and a little more behind, so that the marsupium is located in the middle of the gill, but slightly more anteriorly. The interlaminar connections (See also pl. XLVIII, fig. 4) are developed as rather regularly interrupted septa, forming intercommunicating, incomplete water-tubes. In the middle and at the base of the marsupium, the connections fall also into irregular transverse lines, with a suggestion of quincuncial arrangement. In young females, the marsupial part of the inner gill is considerably smaller.

It should be noted that the non-marsupial gills in this species are more nearly normal than in *D. gratus*.

### 27. Diplodon rotundus Spix (1827).

*Diplodon rotundum* and *Unio rotundus* Spix & Wagner, 1827, p. 34, Pl. 25, figs. 3, 4.

*Unio rotundus* Sowerby, XVI, 1868, Pl. 72, fig. 369; Von Ihering, 1890, p. 169, Pl. 9, fig. 10; 1910, p. 139.

*Diplodon* (*Cyclomya*) *rotundus* Simpson, 1900, p. 886; 1914, p. 1282.

*Type-locality.*—Southern Brazil.

*Other Localities.*—Rivers of eastern Brazil (Von Ihering, 1890); Rio S. Francisco, Villa Nova, Sergipe, Brazil (Von Ihering, 1910); Rio Paraguassú, Bahia, Brazil (Von Ihering, 1893, p. 115; 1910); Rio Parahyba do Sul, Rio de Janeiro, Brazil (Von Ihering, 1893, p. 115).

*New Locality.*—Rio S. Francisco, Bom Jesus da Lapa, Bahia, Brazil (J. D. Haseman coll., December 17, 1907). Two odd right valves.

In the Carnegie Museum there is another, complete specimen from the Hartman collection without locality.

*Distribution.*—Known from the lower and middle part of the Rio S. Francisco, Rio Paraguassú, and Rio Parahyba do Sul in eastern Brazil.

According to the descriptions given by Von Ihering and Simpson my specimens belong here, but my material is too scanty to give a full account of the species.

However, it should be said that of all species of the group this one most nearly approaches the circular outline. It has been placed by Simpson, for this reason, in the subgenus *Cyclomya*, but, as has been indicated already by Von Ihering, there are specimens with the anterior part of the ventral margin less convex. The figures of the type (Spix and Von Ihering) clearly show the oblique shape of the shell, with the highest part more posterior, at, or behind, the posterior end of the ligament; and there is thus no question that this species falls into the same group with *fontainianus* and *gratus*.

Von Ihering (1893, p. 93) emphasizes the separation of the anterior protractor-scar from the adductor-scar. In my specimens, this separation is not so distinct, but only partial, so that we must not lay too much stress upon this character.

MEASUREMENTS.

| Loc. | Length. | Height. | Depth. | Beaks. | Greatest Height. |
|---|---|---|---|---|---|
| Bom Jesus . | 44 mm. | 38 mm. =86 pr. ct. of L. | 20 mm. =45 pr. ct. of L. | at 11 mm. =25 pr. ct. of L. | at 27 mm. =61 pr. ct. of L. |
| ? | 55 " | 48 " =87 " | 22.5 " =41 " | 12.5 " =23 " | 34 " =62 " |
| Bom Jesus . | 66 " | 57 " =86 " | 32 " =48 " | 15 " =23 " | 41 " =62 " |
| (V.Iher. 1890).. | 38 " | 32 " =84 " | 16 " =42 " | 10 " =26 " | |

According to Von Ihering (1910, p. 139), this species reaches the length of 75 mm.

### Subgenus: CYCLOMYA Simpson (1900).

As has been stated, I restrict this subgenus to those shells which have a subrotund outline, with the greatest height located at about the middle of the shell, that is to say, vertically below the middle of the ligament. The posterior part of the shell is thus rather short, the shell is not obliquely subtrapezoidal, as in the species of the *ellipticus*-group, but rather pentagonal in outline. The species at hand is rather large and heavy, and belongs to the largest forms known in the genus.

### 28. DIPLODON (CYCLOMYA) PARANENSIS (Lea) (1834).

*Shells:* Plate XXXIX, figs. 6, 7.

*Unio paranensis* LEA, Obs. I., 1834, Pl. 14, fig. 42; D'ORBIGNY, 1843, p. 603; SOWERBY, XVI, 1866, Pl. 51, fig. 268; CORSI, 1901, p. 451.

*Diplodon* (*Cyclomya*) *paranensis* SIMPSON, 1900, p. 887; 1914, p. 1284.

*Unio nocturnus* LEA, Obs. X, 1863, Pl. 42, fig. 288.

*Diplodon* (*Cyclomya*) *nocturnus* SIMPSON, 1914, p. 1285.

*Unio paraguayanus* VON MARTENS, 1895, p. 34.

*Type-locality.*—Rio Paraná.

*Other Localities.*—Rio Uruguay (D'Orbigny) (Lea, *nocturnus*); Rio Paraná up to above Corrientes (D'Orbigny); Rio Paraguay (Von Ihering, 1893, p. 119); Rio Paraguay, 25° S. Lat. (Von Martens) (This is near Asunción, Paraguay).

*New Localities.*—Rio Paraguay, Corumbá, Matto Grosso, Brazil (H. H. Smith coll.). One large complete shell, one small left valve. In swamp of Lambaré, five miles below Asunción, Paraguay (J. D. Haseman coll., March 31, 1909). One right, one left valve. Rio de la Plata, San Isidro, Argentina (20 *km.* North of Buenos Aires) (A. Windhausen coll., January 1917). Five specimens with soft parts, males and barren females.

*Distribution.*—Rio de la Plata, Paraná, and Paraguay, from near Buenos Aires up to Matto Grosso, Brazil; Rio Uruguay.

*Description of Shell.*—Shell solid and rather thick, large (length up to and over 100 mm.). Outline angularly rounded, or broadly ovate, little oblique. Height generally over 80 pr. ct. of the length, rarely less (lowest figure known 76 pr. ct., but this stands rather isolated, being found in a specimen measured by Simpson). Valves closed, or very little gaping in front. Dorsal margin gently curved or straight (when young), descending anteriorly and passing into the anterior margin, without forming a distinct angle. Posteriorly the dorsal margin forms a more or less distinctly rounded angle with the posterior margin. The latter descends obliquely and is straight, or even a little concave; then it curves around in a sharp curve into the postero-ventral margin, this curve forming a blunt posterior point of the shell, well elevated above the basal line. The ventral margin has a sharp curve near its middle, forming a blunt, projecting angle at, or a little behind, the middle of the shell. The highest part of the shell is at 50 to 60 pr. ct. of the length. This ventral angle is generally distinct, but may be indistinct. From this projection the lower margin slopes upward in either direction, backward and forward, but the anterior part ascends more strongly, and is longer than the posterior, and is often almost straight part of the way, before it finally curves up into the anterior margin. The shell thus appears somewhat narrower anteriorly than posteriorly, and has a rounded pentagonal shape, the five angles being formed by: 1, the beaks; 2, the upper posterior angle; 3, the posterior end; 4, the middle of the lower margin; 5, the anterior end.

Valves not much swollen, moderately convex over the disk, but slightly flattened on both sides of a submedian more convex ridge. The latter runs toward the projection of the lower margin, but is very faintly marked. Posterior ridge rather distinct on account of a distinct radial depression behind it. This depression makes the posterior slope much compressed, like a narrow wing. The slight

emargination of the posterior margin corresponds to this depression. Diameter 40 to 46 pr. ct. of the length (according to Lea's figure a little less, about 38 pr. ct.) Beaks not swollen, and very slightly prominent beyond the hinge-line. Beak-sculpture variable, but always more or less heavy, covering from 15 to 27 mm. of the shell. There are about a dozen or more radial bars in front of the posterior ridge, of which the anterior and posterior ones are narrow, while those in the middle are thick and blunt. These ridges are very irregular; some anastomose, smaller ones may be intercalated between the larger ones, or they may be connected laterally. In some specimens the beak-sculpture is much less developed, but traces of the heavy ridges are always visible. Toward the lower margin, the beak-sculpture, when well developed, stops suddenly. In addition, there are upon the posterior slope a number of fine, oblique wrinkles, but these are only well-developed in young individuals. In the larger specimens there is a short lunula, which is narrow or very narrow.

Epidermis smooth, but with numerous irregular concentric wrinkles, which are always crossed by more or less distinct radially impressed lines, forming here and there low ridges. Where the beak-sculpture is well preserved, it is seen that this radial sculpture is not a direct continuation of the beak-sculpture, but is independent of it, beginning before the latter ends. In fact, the beginning of this sculpture causes, in part, the irregularities of the beak-sculpture. Color of epidermis yellowish brown to dark brown, generally darker posteriorly, without any distinct color markings. Sometimes there are greenish olive tints towards the beaks.

Hinge-line gently curved. Ligamental sinus shallow, over the middle of the lateral teeth. Lateral teeth strong, moderately long, one in right, two in left valve, descending posteriorly. In the youngest specimens, the upper margin is somewhat elevated above the posterior ends of the laterals, while in the others it is less elevated, almost parallel to them. Pseudocardinals strong, ragged, compressed, running obliquely forward and downward, straight or curved. In the right valve there are two pseudocardinals, the posterior higher and stronger, much cut up. In the left valve there is one strong tooth, much cut up, and sometimes a much smaller one behind it, which, however, may be absent. There is much variation in the raggedness of the pseudocardinals.

Cavity of beaks and shell rather shallow. Nacre whitish or lurid, iridescent. Anterior adductor-scar well impressed, subcircular, or subelliptical. Anterior retractor-scar small, rounded, above the adductor-scar and separated from it. Anterior protractor-scar rounded, connected with adductor-scar. Posterior ad-

ductor-scar faintly impressed, almost pear-shaped, subovate or subtriangular, with an upper triangular process formed by the posterior retractor-scar. Mantle-line distinct, remote from the margin about one-fourth to one-fifth (or less) of the height of the shell. Dorsal scars about five (more or less), in beak-cavity in an irregular, longitudinal row, sometimes shifted a little toward the narrow hinge-plate.

MEASUREMENTS.[21]

| No. | Sex. | Length. | Height. % L. | Diameter. % L. | Beaks at % L. | Greatest Height at % L. | Fig. |
|---|---|---|---|---|---|---|---|
| Corumbá . . . | | 45 mm. | 36 mm. = 80 | 20 mm. = 44 | 16 mm. = 36 | 23 mm. = 51 | Pl. XXXIX f. 7. |
| S. Isidro. . . . | ♀ | 76 " | 66 " = 87 | 33 " = 43 | 20 " = 26 | 39 " = 51 | |
| Asunción . . . | | 85 " | 69 " = 81 | 34 " = 40 | 25 " = 29 | 47 " = 55 | |
| S. Isidro *a*. . . | ♀ | 86.5 " | 74.5 " = 86 | 36 " = 42 | 23 " = 27 | 45 " = 52 | Pl. XXXIX f. 6. |
| Do. *b*. . . | ♀ | 90 " | 77 " = 86 | 40.5 " = 45 | 25 " = 28 | 45 " = 50 | |
| Do. *c*. . . | ♂ | 91 " | 77 " = 85 | 42 " = 46 | 27 " = 30 | 47 " = 52 | |
| Do. *d*. . . | ♂ | 92 " | 80 " = 87 | 39.5 " = 43 | 27 " = 29 | 55 " = 60 | |
| Corumbá . . . | | 96 " | 81 " = 84 | 41 " = 43 | 24 " = 25 | 50 " = 52 | |
| Lea's figure . | . . | 86 " | 77 " = 90 | 33 " = 38 | 29 " = 34 | 46 " = 53 | |
| Simpson. . . . | . . | 92 " | 78 " = 85 | 38 " = 41 | | | |
| Do. . . . . | . . | 100 " | 76 " = 76 | 47 " = 47 | | | |
| D'Orbigny. . | . . | 101 " | = 86 | = 37 | | | |

*Remarks.*—Lea has described two other large, subrotund species from the Uruguay River: *nocturnus* and *funebralis* (Obs. X, 1863, Pl. 42, fig. 288, and Pl. 41, fig. 286). Of these, *funebralis* is similar in general shape and proportions, with the exception of the much greater compression of the valves. The diameter is only 30 pr. ct. according to the figure and the measurements given by Simpson (1914 p. 1284), which falls far below of any of the measurements known for *paranensis*. In addition, in *funebralis*, the mantle-line is unusually far remote from the margin of the shell, and, according to our present knowledge, we must consider these characters as sufficient to separate the two species.

*U. nocturnus* was united with *paranensis* by Simpson in 1900, but in 1914 he separated them again. The proportions of *nocturnus* are:

| | Length. | Height. | Diameter. | Beaks. | Greatest Height. |
|---|---|---|---|---|---|
| Lea's figure . . . | 72 mm. | 60 mm. = 83 pr. ct. of L. | 30 mm. = 41 pr. ct. of L. | at 21 mm. = 29 pr. ct. of L. | at 37 mm. = 51 pr. ct. of L. |
| Simpson's measur. . | 72 " | 60 " = 83 " | 28 " = 39 " | | |

Thus there is no essential difference from *paranensis*, and according to Simpson's account, I can find only a difference in the color of the epidermis, which is

[21] More care must be taken in this species than in others to place the ligament horizontally, and to measure parallel and vertical to it. The greatest height of the shell is hard to locate, and allowance should be made for this.

said to be bottle-green, almost black posteriorly, in *nocturnus*. I do not think that this is sufficient to separate *nocturnus* from *paranensis*, since in the latter olive-green tints may also be noticed. This is seen chiefly in a specimen from the Hartman collection, without locality, preserved in the Carnegie Museum. Moreover, the original description of Lea's *paranensis* mentions this color.

The variability of the beak-sculpture of this species is remarkable. It has never been described in detail, except that it consists of rather heavy radial bars. In most of my specimens these bars are rather short (hardly more than 15 mm. long), but in three (all isolated valves, two from Asunción, one young from Corumbá) it extends farther, 25 to 27 mm., and chiefly in the young one (Pl. XXXIX, f. 7) this is very striking, since in this case the beak-sculpture extends over nearly half of the shell. I see, however, no other difference in these specimens, and even among them the bars are not uniform in length. I believe that *U. paraguayanus* Von Martens is founded upon such specimens. The dimensions of this fall easily within the range of variation of *paranensis*. According to Von Martens they are: length 102 mm.; height 82 mm. = 80 pr. ct. of length; diameter 47 mm. = 46 per. ct. of length. The location of the beaks is given as "three-fourths of the length," which probably corresponds to 25 pr. ct. of length, we measuring from the anterior extremity, the author having reversed the procedure.

Von Martens compares his species with *nocturnus*, but says that it is larger, with stronger sculpture (meaning apparently the beak-sculpture), and larger hinge-teeth, but all these characters are unreliable, and do not distinguish it from *paranensis*.

*Anatomy*.—The soft parts of two males and three barren females from San Isidro are at hand.

Color whitish, distal part of foot gray.

Anal opening closed above; the closed part being two to three times as long as the open, which is slit-like, and shorter than the branchial opening. Anal and branchial separated by a solid mantle-connection. Branchial opening with small, but distinct, papillæ. Palpi subtriangular, lower margins curved, posterior margins connected for about one-third of their length.

Gills moderately wide, posteriorly of about the same width, but anteriorly the inner gill is much wider. The shape of the latter is subtrapezoidal, that of the outer gill subtriangular. Anterior end of outer gill near the highest point of the mantle-attachment-line, that of the inner gill immediately behind the palpi. Inner lamina of inner gill entirely connected with abdominal sac.

Structure of non-marsupial gills as usual, with few and scattered interlaminar

connections. *Marsupium* of the female located in the inner gill, but not occupying all of it, leaving about one-fourth or a little less free at the anterior and the posterior end. In younger specimens the marsupial part is smaller, but also has a median position. Interlaminar connections of the marsupium forming interrupted septa, without any distinct transverse or quincuncial arrangement.

### Final Remarks on the Genus Diplodon.

It is not claimed that the above arrangement of the species of *Diplodon* should be regarded as in any sense final. Even the two subgenera, *Diplodon* and *Cyclomya*, cannot be sharply separated: they are intimately connected with each other, and *Cyclomya* is allied with the *ellipticus*-group of *Diplodon* through species like *rotundus, fontainianus,* and *gratus.* The other groups cannot be very sharply defined according to shell-characters. It is to be hoped that the anatomy may furnish better criteria for the grouping of the species; but unfortunately not enough species are known from this point of view, and some of those known are not known fully enough. The characters of the glochidia need further special study. The following facts, however, may be emphasized:

1. In six species of the *chilensis*-group (*frenzeli, imitator, simillimus, vicarius, decipiens, paulista*), the marsupium has a distinct tendency to move forward in the inner gill, and in three of these (*simillimus, vicarius, paulista*), it is entirely anterior to the middle of the gill. In five of these species, the structure of the interlaminar connections is interrupted septiform, or partly reticulate, but in one species (*decipiens*) continuous septa are formed. The glochidia of all these species have hooks.

The tendency of the marsupium to move forward is found in addition only in two species of the *ellipticus*-group (*gratus* and *deceptus*).

2. In the *charruanus*-group (*charruanus, piceus, uruguayensis, hildæ*), the marsupium is rather large and lies in the middle of the gill; sometimes (*hildæ*) it is smaller; and in two cases (*charruanus* and *hildæ*) it has a tendency to move backward. In the *lacteolus*-group (two species, *burroughianus* and *mogymirim*), the marsupium is also located slightly more posteriorly. In most of these species, the interlaminar connections form interrupted septa, in part reticulated. But there is one exception, for *mogymirim* has continuous septa. This structure is thus only known in two species (*mogymirim* and *decipiens*) belonging to different groups.

3. In the *ellipticus*-group, the marsupium may be in the middle of the gill (*enno*), slightly posterior (*berthæ*), or slightly anterior (*gratus, deceptus*). Its

structure may be prevailingly reticulate (*berthæ, enno*), or prevailingly septiform (*gratus, deceptus*).

4. *D. paranensis* has the marsupium in the middle half of the gill, and interrupted septiform structure is present.

5. In eight species, hooks are known to be present on the glochidia. Of these six belong to the *chilensis*-group, one to the *charruanus*-group (*piceus*), one to the *lacteolus*-group (*mogymirim*). Glochidia without hooks (but possibly immature) were found in *charruanus* and *berthæ* (*charruanus*- and *ellipticus*-groups). Two species have margined glochidia, *hasemani* of the *hylæus*-group, and *hildæ* of the *charruanus*-group.

For the present, these facts do not furnish any clue as to the relationship of the species or groups, they even are rather confusing, partly upsetting the divisions arrived at by the study of the shell. But they should be carefully recorded, because additional material may throw more light on the problem.

## Genus CASTALINA Von Ihering (1891).

Von Ihering, 1891, p. 478; 1893, p. 73; Simpson, 1900, p. 865; 1914, p. 1204.

*Type-species.*—*C. martensi* Von Ihering (designated by Simpson).

The chief characters of this genus are found in the general shape of the shell, which is subtriangular or subquadrate, with a well developed posterior ridge and a subtruncated posterior slope, which, however, is somewhat elevated in the middle. In addition, the beaks are rather elevated, the interdentum is well developed, forming a rather deep beak-cavity. The hinge-teeth often are provided with parallel ridges.

The anatomy is similar to that of *Diplodon*. However, there is a tendency to close the branchial opening in front, yet this is not always the case, so that this character is variable, not only specifically, but also individually.

The genus has been well treated by Von Ihering (1893), and a key for the species has been given (p. 83). Simpson (1914 p. 1205) also gives a key, but *C. undosa* should be excluded; it is a *Castalia*.

### 29. Castalina nehringi Von Ihering (1893).[22]

*Diagram of soft parts:* text-fig. 2, p. 456; *Anatomy of gills:* Pl. XLVII, fig. 2; *Section of gills:* Plate XLVIII, fig. 5; *Glochidium:* text-fig. 41, p. 469.

*Type-locality.*—Rio Piracicaba, São Paulo, Brazil.

[22] Of both *C. nehringi* and *martensi* the specific names were first mentioned by Von Ihering in 1891 (p. 477), but as *nomina nuda* without descriptions.

*Material Represented in the Carnegie Museum.*—Rio Piracicaba, São Paulo, Brazil (Von Ihering, donor, cotypes or topotypes). Two specimens. Rio Tieté, Salto das Cruzes, São Paulo, Brazil (J. D. Haseman coll., September 22, 1908). Four specimens, two of them with soft parts. Rio Tieté, 25 miles above Itapura, São Paulo, Brazil (J. D. Haseman coll., September 27, 1908). Eight specimens, six of them with soft parts.

*Distribution.*—Rio Tieté and Rio Piracicaba in São Paulo, headwaters of Rio Paraná.

Von Ihering has given a detailed description of this species, pointing out its differences from the allied species. He believes that specimens with the beaks more distant from the anterior margin are males. I cannot control this, since I have no males among those of my specimens with soft parts, but the percentage given for the location of the beaks in the males (28 to 30 pr. ct.) is not represented in my measurements, and this would tend to confirm Von Ihering's observation. It is to be noted that my smallest specimens (Nos. 1 to 5 from Itapura) exceed in height the figures given by Von Ihering, and thus young shells are proportionally higher: the older ones become longer on account of a prolongation of the posterior end of the shell (best seen in No. 6 from Itapura).

MEASUREMENTS.

| | No. | Sex. | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|---|---|
| Itapura | 1 | ♀ | 51 mm. | 46 mm. = 90 pr. ct. of L. | 26 mm. = 51 pr. ct. of L. | at 9 mm. = 18 pr. ct. of L. |
| Do. | 5 | ♀ | 54 " | 46.5 " = 86 " | 29.5 " = 55 " | 11 " = 20 " |
| Do. | 3 | ♀ | 55 " | 48 " = 87 " | 26 " = 47 " | 10.5 " = 19 " |
| Salto das Cruzes | 1 | ♀ | 61.5 " | 49.5 " = 80 " | 31 " = 50 " | 12 " = 20 " |
| Do. | 2 | ♀ | 69 " | 55.5 " = 80 " | 34 " = 49 " | 15 " = 22 " |
| Itapura | 6 | ♀ | 81 " | 64 " = 79 " | 40 " = 49 " | 15.5 " = 19 " |

*Anatomy.*—I have the soft parts of eight specimens, all of which are females, three of them gravid. One of the latter had eggs; one had immature, and the third mature glochidia. For the breeding season the dates of collection (September 22 and 27) should be noted. (Mature glochidia were found on Sept. 22.)

Von Ihering (1893, p. 79) describes the soft parts of two males. Of these, one had the branchial opening closed in front, the other open. This is the species of *Castalina*, to which I have referred previously (Ortmann, 1911, p. 118). In none of my females is there an anterior mantle-connection in front of the branchial opening. Therefore this seems to be the normal condition in this species, although it should be born in mind that this connection at its best is very slight, and might be easily torn by rough handling.

The anal opening is described by Von Ihering as also differing in his two

specimens. He mentions the presence in one of a supra-anal opening; but is not quite positive that this is natural. According to my material, the anal is always closed above, without forming a supra-anal (text-fig. 2, *s*, p. 456). The soft parts have the following characters:

Anal opening closed above; open part (text-fig. 2, *a* p. 456) short, somewhat shorter than the branchial, slit-like, its inner margin indistinctly crenulated or smooth. Closed part (*s*) about three to four times as long as the open part. A supra-anal canal extends all the way under the closed part (above the rectum), ending blindly above. Mantle-connection between anal and branchial openings well developed (text-fig. 2, *t*). Branchial opening (*b*) with well developed papillæ on inner margin, which show some irregularities at the anterior end of the opening, but in none of my specimens are distinct traces of a connection of the mantle margins in this region visible. Palpi (*h*) large, subtriangular, almost falciform, with long and curved lower margins, and short posterior margins, the latter connected for about one half of their length.

Gills (text-fig. 2, *i*, *o*) moderately wide, the inner (*i*) distinctly wider, chiefly anteriorly. Outer gill (*o*) with gently curved edge, its anterior end near the highest point of the mantle-attachment-line. Inner gill with the edge almost straight, anteriorly a little narrower, and broadly attached, the attachment occupying all of the space between the anterior end of the outer gill and the palpi (*h*). Inner lamina of inner gill entirely connected with abdominal sac. In the female (Pl. XLVII, fig. 2) the inner gill is *marsupial*, but only a section of the gill possesses this character, with the interlaminar connections distinctly arranged in interrupted septa (See also Pl. XLVIII, fig. 5). The marsupial part is rather small in younger specimens (such as the one figured on Pl. XLVII, fig. 2), lying immediately behind the middle of the gill; but it is larger in older specimens, lying practically in the middle, leaving free about one-third anteriorly as well as posteriorly (text-fig. 2, *i*). The non-marsupial gills have remote, incomplete, interrupted septa, and the septiform structure is more evident than it generally is in *Diplodon* (See outer gill, Pl. XLVII, fig. 2).

When charged, the eggs or glochidia do not form placenta-like masses. The fully developed *glochidium* (text-fig. 4, l, p. 469) is subtriangular, with a lower point situated about in the middle of the lower margin, and with distinct hooks at this point, which differ from those seen in certain species of *Diplodon* in that they are shorter, and broader at the base. L. 0.26 mm.; H. 0.24 mm.; hooks: 0.06 mm. Thus the glochidium is rather small.

30. Castalina martensi Von Ihering (1893).

Von Ihering, 1893, p. 81, Pl. 3, fig. 5; Simpson, 1900, p. 865; 1914, p. 1205.

*Type-locality.*—Rio Camaquam, Rio Grande do Sul, Brazil.

*New locality.*—Rio Jacuhy, Cachoeira, Rio Grande do Sul, Brazil (J. D. Haseman coll., January 27, 1909). Three complete shells and one right valve.

*Distribution.*—Our new locality extends the range of this species northward. The Rio Jacuhy belongs to the Guahyba-system, but both the Guahyba and Camaquam flow into the Lagoa dos Patos. Von Ihering says that he did not find this species north of the Rio Camaquam.

This species has been sufficiently well described by Von Ihering. Our youngest specimen shows well developed beak-sculpture, corresponding to the description. The variations mentioned by Von Ihering in the crenulation of the lateral teeth are also seen in our specimens.

Measurements.

| Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|
| 26 mm. | 21.5 mm. = 83 pr. ct. of L. | 13.5 mm. = 52 pr. ct. of L. | at 8.5 mm. = 33 pr. ct. of L. |
| 48 " | 38 " = 79 " | 24 " = 50 " | 12 " = 25 " |
| 48 " | 40.5 " = 84 " | 26 " = 54 " | 13 " = 27 " |
| 75 " | 55 " = 73 " | 34 " = 45 " | 21 " = 29 " Largest specimen of Von Ihering) |

The height ranges according to Von Ihering from 70 to 79 pr. ct., and the diameter from 45 to 50 pr. ct. The location of the beaks is from 21 to 29 pr. ct. Thus our specimens are comparatively higher and more swollen. As far as concerns the height, this is certainly due to the smaller size of my shells, since a similar change in the proportional height with age has been observed in *C. nehringi*.

*Anatomy.*—Of this species Von Ihering (1891, p. 477) says that in most cases (seven out of eight) the branchial opening is closed in front. I do not possess the soft parts.

31. Castalina psammoica (D'Orbigny) (1835).

*Unio psammoica* D'Orbigny, 1843, p. 608, Pl. 71, figs. 4–7; Sowerby, XVI, 1868, Pl. 93, fig. 507.

*Castalina psammoica* Von Ihering, 1893, p. 79; Von Martens, 1894, p. 164; Simpson, 1900, p. 866; 1914, p. 1206; Haas, 1916, pp. 9, 47.

*Type-locality.*—Rio Paraná, Itaty, above Corrientes, Argentina.

*Other Localities.*—Province Santa Fé, Argentina (D'Orbigny) (farther down the Paraná); Rio Paraguay, near mouth of Rio Apa (Von Ihering) (in Paraguay, at Brazilian boundary); Paraguay (Von Martens); Rio Uruguay, Salto Oriental, Uruguay (Haas).

*New Localities.*—Rio Uruguay (in mud), Uruguayana, Rio Grande do Sul, Brazil (J. D. Haseman coll., February 5, 1909). One young male with soft parts. Rio de la Plata, San Isidro, 20 *km.* north of Buenos Aires, Argentina (A. Windhausen coll., January 1917). One male with soft parts.

*Distribution.*—From the La Plata near Buenos Aires up to the Rio Paraná and Rio Paraguay in Paraguay, and also in the Rio Uruguay.

The descriptions given by D'Orbigny, Von Ihering, and Simpson agree well with our specimens, but it should be mentioned that the beak-sculpture sometimes covers less than half of the adult shell. The hinge-teeth are very variable, but Von Ihering's account represents the normal condition. The laterals are said to be smooth or finely smoothly striated. In my young specimen they have distinct, vertical, irregular, and granular ridges; in my larger specimen they are irregularly granular and crenulated, but have no distinct vertical ridges.

According to Von Ihering, the maximum length is 70 mm.; according to D'Orbigny, 75 mm. The height according to the former is 77 to 80 pr. ct.; according to the latter, 76 pr. ct.; the diameter is 50 and 49 pr. ct. respectively. The beaks are located, according to Von Ihering at 17 to 23 pr. ct. of the length.

MEASUREMENTS.

| Localities. | Sex. | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|---|
| Uruguayana.......... | ♂ | 44 mm. | 35 mm. = 80 pr. ct. of L. | 23 mm. = 52 pr. ct. of L. | at 10.5 mm. = 24 pr. ct. of L. |
| San Isidro............ | ♂ | 62 " | 50 " = 81 " | 37.5 " = 60 " | 14 " = 23 " |

Thus our larger specimen is unusually swollen.

*Remarks.*—This species somewhat resembles the genus *Castalia,* chiefly on account of the strong development of the beak-sculpture. However, according to the posterior slope, which is distinctly elevated along the upper posterior margin, and also according to the structure of the lateral teeth, which have the vertical ridges poorly, or not at all, developed, it is a *Castalina.* In *Castalia* furthermore the diameter of the shell generally is much greater than the maximum (60 pr. ct.) observed in the present species.

*Anatomy.*—Soft parts of two males at hand. Color whitish.

Anal opening slit-like, closed above; closed part three to four times as long as the open, the latter shorter than the branchial opening, and separated from it by a solid mantle-connection. Branchial with small papillæ. In the smaller specimen, the branchial opening is closed in front by a firm union of the mantle-margins, but in the larger specimen there is no such connection, and thus in this species this character is variable. Palpi rather large, nearly subfalciform, with the lower

margins long and strongly curved, posterior margins short, and united at base for about one-fourth of their length.

Inner gills much wider than the outer, chiefly in front; only for a short distance behind have they an equal width. Outer gill with curved margin, anterior end at highest point of mantle-attachment-line. Inner gill with margin nearly straight, broadly attached anteriorly, and anterior end close to the palpi. Inner lamina of inner gill entirely connected with abdominal sac. Structure of non-marsupial gills normal, with scattered interlaminar connections, assuming here and there the shape of short, weak septa.

### Genus CASTALIA Lamarck (1819).

*Castalia* Lamarck, 1819, p. 66; Pilsbry, 1911, p. 610.

*Tetraplodon* Spix, 1827, Pl. 25; Pilsbry, 1893, p. 90; Simpson, 1900, p. 863; 1914, p. 1194.

Pilsbry (1911) has brought to light the fact that Savigny's genus *Castalia* (*Vermes*) is not to be dated from 1817, but that it is later (certainly not before 1820, probably as late as 1826), so that *Castalia* applied by Lamarck (1819) to the present genus has to stand.

*Castalia* is distinguished by the triangular outline, with high beaks, well developed posterior ridge, great obesity of the shell, truncated posterior slope, and well developed beak-sculpture, which extends over a large part of the shell. It is to be noted, however, that the truncation of the posterior slope often varies with age, so that in very young specimens it is somewhat elevated in the middle, giving an outline to the shell approaching the subtrapezoidal or subrhomboidal. With one exception the species resemble each other very closely. This exception is *C. undosa*, which differs from all the rest in having strong, oblique folds, or ribs, upon the posterior slope.

My material of *Castalia* is rather insufficient, and I have had great difficulties in determining the species. The key given by Simpson (1914) is useless for the reason that the type-species (*ambigua*) has been misunderstood. The latter has been redescribed and figured by Von Ihering (1910),[23] which fact had been neglected by Simpson. At the same time Von Ihering has given an elaborate key for the species. However, this also is unsatisfactory, and I am afraid that Von Ihering has not paid proper attention to the changes undergone by the shell with advancing

[23] In this connection it should be mentioned that Wyatt, T. (A Manual of Conchology, 1838, p. 65, Pl. 11, fig. 5) has given a recognizable figure of *C. ambigua*, which undoubtedly represents the genuine *ambigua*, as determined by Von Ihering).

age. In trying to use this key, I generally met with the difficulty that my specimens were intermediate between the alternatives given in it. But, as I said, my material is too scanty to bring order out of this confusion, yet I shall try my best to give an account of the material at hand.

The geographical distribution of the species of this genus is interesting. According to Von Ihering (1910, p. 130) their metropolis is in the Amazon-drainage, whence the forms extend into Guyana and the upper Paraná-drainage. But on account of the great uncertainty prevailing with regard to the various species no details can be given.

### 32. Castalia acuticosta Hupé (1857).

*Glochidium:* Text-fig. 4, *m*, p. 469.

*Castalia acuticosta* Hupé, 1857, p. 77, Pl. 14, fig. 3; Sowerby, XVII. 1869, Pl. 3, fig. 12.

*Tetraplodon acuticosta* Von Ihering, 1910, p. 128.

*Type-locality.*—Brazil. (Von Ihering says that Castelnau collected this species in Goyaz, but I cannot find this fact mentioned in Hupé's paper.)

*Other Localities.*—Rio Araguay, Goyaz, Brazil (Von Ihering, 1910, p. 135); Lagoa do Coral, Goyaz, Brazil (Von Ihering) (drainage of Rio Araguay, tributary to Tocantins).

*New Localities.*—Sand-bar of Rio Tapajos, Santarem, Pará, Brazil (J. D. Haseman coll., December 6–12, 1909). Eight specimens, one of them a male with soft parts. Center of Rio Guaporé, near Rio São Simão, Matto Grosso, Brazil (J. D. Haseman coll., July 20, 1909). Three specimens, with soft parts, male, and gravid females. Rio Guaporé, São Antonio de Guaporé, Matto Grosso, Brazil (J. D. Haseman coll., July 31, 1909). Four specimens. Rio Machupo, San Joaquim, Bolivia (J. D. Haseman coll., September 1, 1909). Three young specimens, with soft parts, probably males.

In addition, the Carnegie Museum possesses a fine specimen from the Juny collection, without locality.

*Distribution.*—Southern tributaries of the Amazon, from Tocantins and Araguay in Goyaz, and Rio Tapajos in Pará, to the Madeira (Guaporé and Machupo) in Matto Grosso and Bolivia.

This species belongs to those with elevated beaks, although the beaks are here far less prominent than in *turgida*, *baro*, and *hanleyana*. It is a small species (maximum length 35 mm.); but that specimens about 25 mm. long are mature is shown by the fact that at that size they may be gravid.

The outline is "subquadrate" according to Von Ihering. I should call it rather subtrapezoidal or subrhomboidal, and this is due to the fact that the posterior end is not much produced, and that the angle between the upper and the posterior margins is somewhat prominent; consequently, the posterior slope is not so much truncated as in other species, but a little elevated toward the upper posterior angle. On account of the shortness of the shell, the beaks are comparatively remote from the anterior end.

Von Ihering has pointed out that there are variations in the beak-sculpture, and I observe this also in my specimens. In most cases it is sharp; the bars are narrow and distinct, and extend to the lower margin of the shell. But sometimes the bars are more rounded, less distinct, and may not reach the lower margin. A few finer radial bars are generally present upon the posterior slope.

MEASUREMENTS.

| Localities. | No. | Sex. | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|---|---|
| Santarem ........... | 2 | ? | 18.5 mm. | 16 mm. =86 pr. ct. of L. | 14 mm. =76 pr. ct. of L. | at 5.5 mm. =24 pr. ct. of L. |
| Do. ........... | 3 | ♂ | 20 " | 18 " =90 " | 17 " =85 " | 6.5 " =33 " |
| Guaporé ............ | 2 | ♀ | 24 " | 20 " =83 " | 19 " =79 " | 6.5 " =27 " |
| Do. ............ | 1 | ♀ | 24 " | 20.5 " =85 " | 18 " =75 " | 6 " =25 " |
| Do. ............ | 3 | ♂ | 28 " | 24.5 " =88 " | 21 " =75 " | 8 " =29 " |
| Santarem ........... | 6 | ? | 29 " | 25 " =86 " | 22 " =76 " | 8.5 " =29 " |
| ? ........... | | ? | 30 " | 27 " =90 " | 23 " =77 " | 10 " =33 " |
| Hupé, text-figure..... | | | 34 " | 26 " =76 " | 23 " =68 " | |

It should be remarked that Hupé's figure of the diameter (half shell) does not agree with his measurements in the text. This figure would give a diameter of only 18 mm. (= 53 pr. ct.,) while the text gives 68 pr. ct. Both height and diameter of Hupé's shell are less than in any of mine. Von Ihering gives the location of the beaks at 39 to 41 pr. ct. of the length, which is much greater than the figures of Hupé (31 pr. ct. according to the figure) and of my shells. But I believe that this discrepancy is due to a different way of measuring: I always measure parallel to the ligament.

*Remarks.*—My specimens certainly belong together; but I am not quite positive that they might not be only the young stage of some other species (*hanleyana* or *baro*). The fact that some of mine are gravid does not demonstrate that they are adult or nearly adult, for we know that other *Naiades* become sexually mature, when yet rather small. The further fact that those from Santarem were found associated with *baro* and *hanleyana* indicates that they may belong to these species. However, I am unable to decide this question.

*Anatomy.*—Soft parts of two males and two gravid females (with glochidia) at hand. The latter were found on July 20. Color of soft parts whitish.

Anal opening slit-like, closed above; closed part about four to five times as long as the open, the latter separated from the branchial opening by a solid mantle-connection. Branchial opening with small papillæ, closed in front by a mantle-connection in the two males and in one of the females, while in the other female this connection is missing (but it may be torn). Palpi moderately large, subtriangular, with curved lower margins, and the posterior margins united for about one-fourth of their length.

Gills about equally wide posteriorly, anteriorly the inner is the wider, of the usual shape. Inner lamina of inner gill entirely connected with the abdominal sac. Non-marsupial gills with scattered interlaminar connections. *Marsupium* in the middle of the inner gill, leaving about one-fourth of the gill free at the anterior end, and a little less at the posterior. Interlaminar connections interrupted, but their arrangement cannot be clearly seen, since no barren females are at hand.

Glochidium (text-fig. 4, *m*, p. 469) subtriangular, with a point at about the middle of the lower margin, and with hooks of the usual shape, but rather short. L. and H. about 0.24 mm., hooks 0.05 mm. Thus the glochidium is rather small.

### 33. Castalia hanleyana Sowerby (1869).

*Castalia hanleyana* Sowerby, XVII, 1869, Pl. 1, f. 5.
*Tetraplodon hanleyanus* Von Ihering, 1910, p. 127.

*Type-locality.*—Unknown.

*Other Localities.*—Rio Araguaya, Ilha Bananal, Goyaz, Brazil (Von Ihering); State of Pará, Brazil (Von Ihering).

*New Locality.*—Sand bar of Rio Tapajos, Santarem, Pará, Brazil (J. D. Haseman coll., December 6–12, 1909). Two odd valves (right and left).

*Distribution.*—It should be noted that this species is found, where also *acuticosta* occurs, in the Rio Araguaya and the Rio Tapajos.

My two valves agree well with the account given by Von Ihering, and with Sowerby's figure, but are smaller than the latter.

Measurements.

| Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|
| 42.5 mm. | 35 mm. = 82 pr. ct. of L. | 28 mm. = 66 pr. ct. of L. | at 12 mm. = 28 pr. ct. of L. |
| 36.5 " | 31 " = 85 " | 27 " = 74 " | 10.5 " = 29 " |

*Remarks.*—According to Von Ihering, the beaks are at 30 to 33 pr. ct., while my specimens show lower figures. But this fact may be due to a different way of measuring. The shell is characterized by high beaks and its high, triangular (not

elongated) shape, which makes the beaks appear to be rather far back (in comparison with *baro*). However, this may be only a more aged form of *acuticosta*.

### 34. Castalia baro (Von Ihering) (1910)

*Castalia ambigua* Sowerby (not Lamarck), XVII, 1869, Pl. 1, fig. 1.
*Tetraplodon baro* Von Ihering, 1910, p. 127; Simpson, 1914, p. 1198.

*Type-locality.*—Amazon River.

*New Locality:* Sand bar of Rio Tapajos, Santarem, Pará, Brazil (J. D. Haseman coll., December 6–12, 1909). One complete shell, two odd valves, right and left.

In addition the Carnegie Museum has two other fine specimens, one from the Holland collection, labeled "River Amazon," the other from the Juny collection, without locality.

*Distribution:* Amazon and Tapajos Rivers.

This species stands very close to *C. hanleyana*, and differs only in its more elongated shape, and, consequently, more anterior beaks. Von Ihering says that the lower margin is straight (while it is convex in *hanleyana*). But this feature is somewhat variable, for it may be gently curved. However it is correct that in *baro* the lower margin is more nearly straight than in *hanleyana*.

I should not be astonished if *hanleyana* and *baro* should finally prove to be only the adult stages of *acuticosta*. The fact that all three have been found by Haseman associated at Santarem is in favor of this view.

About the dimensions of *baro* we only know that the beaks are at 16 pr. ct. of the length. My specimens show a somewhat higher percentage, but not as high as in *hanleyana* (where it is from 28 to 33 pr. ct.).

Measurements.

| Localities. | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|
| Santarem.. | 39 mm. | 28 mm. = 73 pr. ct. of L. | 27 mm. = 69 pr. ct. of L. | at 9 mm. = 23 pr. ct. of L. |
| Do. .. | 45.5 " | 33 " = 73 " | 30.5 " = 67 " | 9 " = 20 " |
| Amazon... | 48 " | 35 " = 73 " | 32 " = 67 " | 10.5 " = 22 " |
| (Juny).... | 52.5 " | 39.5 " = 75 " | 37 " = 72 " | 10 " = 19 " |
| Santarem.. | 55 " | 40 " = 73 " | 36 " = 65 " | 10 " = 18 " |

### 35. Castalia pectinata (Spix) (1827).

*Tetraplodon pectinatum* Spix, 1827, Pl. 25, fig. 3; Von Ihering, 1910, p. 125.
*Unio pectinatus* Wagner, 1827, p. 32.
*Castalia ambigua* Von Ihering (not Lamarck), 1890, p. 162.

*Type-locality.*—Rio São Francisco, Minas Geraes, Brazil.

*New Localities.*—Amazon River, Pará, Brazil (Hartman collection). Two specimens. Sand bar of Rio Tapajos, Santarem, Pará, Brazil (J. D. Haseman coll., December 6–12, 1909). One odd (right) valve.

*Distribution.*—Known hitherto only from the Rio São Francisco, and only from the description and figure of Spix and Wagner. Its discovery in the Amazon and Tapajos in Pará thus extends its range into the lower basin of the Amazon.

The characters of this species have been established by Von Ihering, and, although it is hazardous to define an old, often misunderstood, and poorly figured form, without having abundant material, the fact that our specimens well agree with the account given by Von Ihering, demonstrates that he is right. The chief characters of this species are found in the low beaks, the rather elongated outline, and rather anterior position of the beaks. The beak-sculpture is described as "mostly" reaching the ventral margin. This is actually the case in one of our specimens from the Amazon and in the half shell from the Tapajos. In the other individual from the Amazon the radial bars are shorter and cover only a little more than half of the shell.

MEASUREMENTS.

| Locality. | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|
| Amazon... | 28 mm. | 21.5 mm.=77 pr. ct. of L. | 17 mm.=61 pr. ct. of L. | at 6 mm.=21 pr. ct.of L. |
| Tapajos... | 28 " | 21 " =75 " | 18 " =64 " | 6.5 " =23 " |
| Amazon... | 31 " | 23 " =74 " | 20 " =65 " | 8 " =26 " |

*Remarks.*—Von Ihering gives the location of the beaks as 25 pr. ct.; my specimens agree with this very well.

*C. juruana* (Von Ihering, 1910, p. 126) from the Rio Jurua (southern tributary of the Amazon in western Brazil) is closely allied. It is founded upon a single specimen, which differs chiefly in the location of the beaks (at 37 pr. ct.), and certain other characters, which at least in part are connected with this. It may finally prove to be only a form of *pectinata*.

Our specimens have about the size given by Wagner in the text (*l. c.*, p. 33) 28 to 31 mm.; while Spix's figures (Pl. 24, figs. 3, 4) are considerably larger (L. over 40 mm.). Thus they apparently are enlarged. *C. juruana* is larger, L. 46 mm.

### 36. CASTALIA INFLATA D'Orbigny. (1835).

*Castalia inflata* D'ORBIGNY, 1835, p. 43.
*Castalia ambigua* D'ORBIGNY, 1843, p. 598, Pl. 72, figs. 4–6.
*Castalia ambigua inflata* VON IHERING, 1893, p. 88.
*Castalia quadrilatera* VON IHERING, 1893, p. 89.

*Tetraplodon inflatus* Von Ihering, 1910, p. 126; 1915, p. 12.

*Type-locality.*—Paraná River, Corrientes, Argentina.

*Other Localities.*—Lower Paraná River (Von Ihering); small tributaries of the Paraná (D'Orbigny); Rio Paraguay, near Rio Apa, Paraguay (Von Ihering); Rio Paraguay, San Luis de Caceres, Matto Grosso, Brazil (Von Ihering).

*Locality Represented in Carnegie Museum.*—Rio Paraguay, San Luis de Caceres, Matto Grosso, Brazil (J. D. Haseman coll., May 24, 1909). Two specimens.

*Distribution.*—Positively known only from the Paraná and Paraguay Rivers in Argentina, Paraguay, and Brazil. Specimens reported from the Amazon-drainage in Bolivia probably do not belong here.

My identification of this species depends partly on Von Ihering's key, partly on D'Orbigny's original description and figures of specimens from Corrientes, and on the locality. It is a species with low beaks, the shell is oval, but for the rest, Von Ihering's key is insufficient: One of my specimens is rather small, and the beak-sculpture reaches the lower margin; in the other, it falls short of it. The beaks are located at 21 and 24 pr. ct. (21 pr. ct. given by Von Ihering). The shell is about as long as in *pectinata*, and is thicker. The bars of the beak-sculpture in my specimen are rather numerous, but not very sharp. The adductor-scars agree with Von Ihering's account. Thus I have no doubt that my specimen represents *C. inflata*, although the essential characters of this species are yet obscure.

Measurements.

| | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|
| | 29 mm. | 23 mm. =79 pr. ct. of L. | 20 mm. =69 pr. ct. of L. | at 6 mm. =21 pr. ct. of L. |
| | 36 " | 26 " =72 " | 22.5 " =63 " | 8.5 " =24 " |
| D'Orbigny's text | 65 " | 75 " | 60 " | |
| D'Orbigny's fig. of specimen from Corrientes | 35 " | 25.5 " =73 " | 24 " =70 " | 8.5 " =24 " |

Von Ihering does not give detailed measurements, but only says that the maximum length is 51 (1893) and 60 mm. (1910).

### 37. Castalia undosa Von Martens (1885).

*Shell:* Plate XXXIX, figs. 8*a–d*.

*Castalia undosa* Von Martens, 1885, p. 148; Von Ihering, 1893, p. 84; Nehring, 1893, p. 165.

*Castalina undosa* Simpson, 1900, p. 866; 1914, p. 1207.

*Tetraplodon undosus* Ortmann, 1911*a*, p. 117, Pl. 6, fig. 7, Pl. 7, fig. 7 (anatomy).

*Type-locality.*—Rio Piracicaba, Piracicaba, São Paulo, Brazil.

*Localities Represented in Carnegie Museum.*—Rio Piracicaba, São Paulo, Brazil (Von Ihering donor, authentic specimens). One complete shell and one odd (left) valve. Rio Tieté, silty river banks, twenty-five miles above Itapura, São Paulo, Brazil (J. D. Haseman coll., September 27, 1908). Four specimens with soft parts, one male and three females. Rio Tieté, Itapura, São Paulo, Brazil (J. D. Haseman coll., September 28, 1908). Five specimens, one of them a male with soft parts.

*Distribution.*—Rio Tieté and Piracicaba of Upper Paraná-drainage in São Paulo, Brazil.

This species has been well described by Von Martens and Von Ihering, and I do not need to add anything, except that the dimensions vary considerably, the height from 71 to 86 pr. ct. and the diameter from 53 to 66 pr. ct. of the length. On the average our specimens are more swollen than the previous measurements would indicate. The most characteristic feature of this species is the quite unique development of the ribs of the posterior slope, which are much stronger than the oblique "wrinkles" often found in species of *Diplodon.*

Simpson has put this species in the genus *Castalina,* but I do not see any reason for this. The posterior slope undoubtedly has the characters of *Castalia.* The species, indeed, stands isolated in the genus, and cannot be confounded with the other species, and for this reason, probably, Von Ihering omitted it in his key (1910).

MEASUREMENTS.

| No. | Sex. | Length. | Height. | Diameter. | Beaks. | Figure. |
|---|---|---|---|---|---|---|
| | ? | 42 mm. | 34 mm. =81 pr. ct. of L. | 26 mm. =62 pr. ct. of L. | at 10 mm. =24 pr. ct. of L. | Pl. XXXIX, fig. 8. |
| *x*........... | ♀ | 46.5 " | 39 " =84 " | 27 " =58 " | 11.5 " =25 " | |
| *b*........... | ♀ | 47 " | 37.5 " =80 " | 31 " =66 " | 11.5 " =24 " | |
| *c*........... | ♀ | 51 " | 38.5 " =75 " | 31 " =61 " | 13 " =25 " | |
| *a*........... | ♂ | 57 " | 44 " =77 " | 33.5 " =59 " | 13.5 " =24 " | |
| | ♂ | 60 " | 47 " =78 " | 36 " =60 " | 14 " =23 " | |
| (Von Martens).. | | 56 " | 48 " =86 " | 30 " =53 " | 2/7 =29 " | |
| (Von Ihering) | | 66 " | 50 " =76 " | 36 " =55 " | | |

*Anatomy.*—The soft parts of two males and three barren females are at hand.

A description has been previously given by myself (1911*a*, p. 117). However, it should be added that in one female investigated the branchial opening is open in front, but probably torn. In another, a male, it is undoubtedly open; this is an old individual, the largest at hand, and here also it may be that it has been injured during life. In the other three specimens (one male and two females), the branchial opening is closed in front. According to Von Ihering (1891, p. 476), this opening is closed in 80 pr. ct. of the cases.

Anal opening closed above; closed part three to four times as long as the open part, the latter slit-like, shorter than the branchial, and separated from the latter by a solid mantle-connection. Branchial opening with papillæ, closed in front by a firm union of the inner mantle-edges, or, more rarely, open and without this connection. Palpi rather large and slightly produced posteriorly, with strongly curved lower margins. Their posterior margins are connected for about one-third of their length.

Gills of the usual shape, the inner much wider in front than the outer, its anterior end close to the palpi. Inner lamina of inner gill entirely connected with abdominal sac. Non-marsupial gills with scattered interlaminar connections. *Marsupium* of the female located in the inner gill, but it does not occupy all of this gill, but only a portion in the middle, leaving free a larger part anteriorly, and a smaller posteriorly, so that the marsupium appears shifted slightly backwards. Interlaminar connections of marsupium arranged in interrupted septa.

### Genus Hyria Lamarck (1819).

*Hyria* Lamarck, 1819, p. 81; Simpson, 1900, p. 868; 1914, p. 1211.

This genus is characterized by the alate shape of the shell, possessing wings both at the anterior and posterior end of the upper margin. In addition the radial beak-sculpture is well developed, covering a considerable part of the shell, the posterior ridge is rounded and broad, and the pseudocardinals are much compressed. The hinge-teeth may be somewhat corrugated, but they do not possess distinct vertical ridges.

The distribution of this genus is restricted to the basin of the Amazon and the rivers of Guyana. A key to the species has been furnished by Simpson (1914, p. 1212), but some of the species may be only forms of others.

### 38. Hyria corrugata Lamarck (1819).

*Hyria corrugata* Lamarck and *H. transversa* Hupé, Simpson, 1900, pp. 868, 869; 1914, p. 1212, 1215.

*Type-locality.*—Unknown.

*Other Localities.*—Rio Solimoes (= middle Amazon) (*Triplodon rugosum* Spix, Wagner, 1827, p. 35); Rio Yavari, Brazil (southern tributary of Amazon, forming a boundary between Brazil and Peru) (Haas, 1916, p. 9, 47).

*New Locality.*—Sand-bar of Rio Tapajos, Santarem, Pará, Brazil (J. D. Haseman coll., December 6–12, 1909). About fifty specimens, among them two females with soft parts.

Several other specimens are preserved in the Carnegie Museum, from the Hartman, Smith, and Juny collections, but all are labelled "Amazon River."

*Distribution.*—According to Simpson Eastern Peru to Guiana; south throughout Brazil. However, the few special localities known are all on the Amazon and its tributaries.

It should be remarked in the first place that all my specimens undoubtedly represent but one species, showing a great deal of variation, the various forms all connected by intergrades.

Simpson describes this species as having a "subrhomboidal" shape and with the beak-sculpture covering only part of the surface. He retains *H. transversa* Hupé (from Brazil) as a distinct species, which has "rhomboidal" shape, and only a "few strong umbonal ridges." Specimens from the Rio Tapajos at hand represent both forms, and pass gradually into each other, so that I am forced to regard *H. transversa* as only an individual variation of *H. corrugata.*

The extreme development of the beak-sculpture, covering the whole shell, is found in *H. rugosissima* Sowerby. Some of my specimens approach this condition, but none fully agree with Sowerby's figure (XVII, *Hyria,* 1869, Pl. 3, fig. 5), so that this form is not represented in my material, and I cannot say whether it is a good species or not.

Sowerby (*l. c.*, Pl. 2, fig. 3) distinguishes *H. exasperata* (British Guyana) from *H. corrugata* (Pl. 1, fig. 1), the former being longer and more compressed, the latter shorter and more swollen. Simpson unites these two; but among my material I have no specimens which corresponds exactly to the *corrugata* of Sowerby. If the two should be different, my specimens would fall under *exasperata* Sowerby (1869) which undoubtedly is synonymous with *Triplodon rugosum* Spix (1829).

Frierson (1915, p. 363) has recently described *H. amazonia.* In outline this easily falls within the range of my specimens of *corrugata,* chiefly specimens with less developed beak-sculpture (*H. transversa* Hupé). But *H. amazonia* is decidedly more swollen. Being founded upon a single specimen, it is impossible to decide whether *amazonia* is a good species.

In shape my specimens vary greatly. They are all rather compressed, but there is some variation in this respect. The greatest irregularity, however, is seen in the outline and beak-sculpture. The wings of the shell are of various sizes, chiefly the posterior one, which may be rather short, or drawn out, broader or narrower, and may be more or less elevated. Sometimes the wings assume freakish shapes, curving up or down, or being deflected laterally. Thus the whole shell is more or less elongated, and more broadly or more narrowly triangular. The

beak-sculpture is generally well developed, and covers all of the shell in young specimens; but in older individuals it disappears near the lower margin, and sometimes it is poorly developed, and present only for a short distance from the beaks (form *transversa* Hupé), but, as stated above, the latter specimens are connected with the typical form by intergrades.

*Anatomy.*—Two females are at hand, one of them gravid, and with eggs (collected December 10).[24]

The soft parts have been previously described and figured by myself (1911*a*, pp. 108, 114, Pl. 6, fig. 6, Pl. 7, fig. 6).

Anal opening closed above; closed part about twice as long as the opening, the latter slit-like, separated from the branchial opening by a mantle-connection. Branchial opening with small papillæ, not closed in front. Palpi rather small, subtriangular, posterior margins not connected.

Gills of the usual shape, the inner much wider anteriorly than the outer, its anterior end close behind the palpi).[25] Inner lamina of inner gill entirely connected with abdominal sac. Non-marsupial gills with scattered interlaminar connections. *Marsupium* of the female in the inner gill, restricted to the middle portion, about one-fourth of the gill at anterior end, and a little less than that at the posterior end being non-marsupial. Interlaminar connections of marsupium crowded and numerous, forming interrupted septa, and assuming in the most central part an irregularly quincuncial (reticulate) arrangement.

### Genus Prisodon Schumacher (1817).

Simpson, 1900, p. 869; 1914, p. 1216.

Closely allied to *Hyria* in the doubly alate shell, but differing in the absence of beak-sculpture, and the strong development of a sharp posterior ridge.

A key to the species has been given by Simpson (1914, p. 1217).

This genus is also characteristic of Guyana and the Amazon-drainage in Brazil.

#### 39. Prisodon alatus (Sowerby) (1869).

*Shells:* Plate XL, figs. 1, 2, 3.

*Hyria alata* Sowerby, XVII, 1869, Pl. 5, fig. 13.
*Prisodon alatus* Simpson, 1900, p. 871; 1914, p. 1220.

*Type-locality.*—Guyana.

[24] The shell of this gravid female approaches the form *transversa*, with the beak-sculpture less developed, but with the shape not very elongated. The other female is a normal *corrugata*, half-grown.

[25] The connection of this gill with the palpi described previously is only accidental, and seen only on one side of the larger female; on the other side, and also in the smaller female, the structure is normal.

*New Locality.*—Sand-bar of Rio Tapajos, Santarem, Pará, Brazil (J. D. Haseman coll., December 6–12, 1909). About sixty specimens, all dead shells.

*Distribution.*—The discovery of this species, hitherto apparently only known from Guyana, in the Amazon-drainage is interesting.

The shell is easily recognized by the relatively short triangular shape, and the excessive development of the anterior and posterior wings. The outline varies a good deal, being longer or shorter, and the lower posterior end of the shell may be blunt or somewhat pointed. The obesity is also variable. The wings are more or less developed, and the posterior one may be longer or shorter, sometimes as long as the rest of the shell, narrower or wider, pointed or blunt. It is directed straight backwards (forming a straight continuation of the hinge-line), chiefly so in young specimens; but in older ones it may be directed more or less upward, so that the hinge-line becomes concave. Upon the posterior slope there are sometimes a few (three to five) parallel folds or wrinkles, but most specimens lack these.

The pseudocardinals (Pl. XL, figs. 2*c*, *d*) of this species are very long and compressed, the posterior of the right valve is longer than the anterior, and extends far forwards, so as to be placed in its anterior part below the anterior. In the left valve there are also two pseudocardinals, the posterior shorter than the anterior, and extending only with its anterior end below the anterior. The upper and inner face of the posterior right pseudocardinal in its posterior part, and the space between the two teeth in the left valve, has distinct, parallel, and subvertical ridges. The lateral teeth (one in right, two in left valve) are only obliquely and granulately corrugated, but do not possess parallel vertical ridges. Thus in the structure of the pseudocardinals this species differs from other species of the genus (I have been able to compare *P. castelnaudi*, *obliquus*, *brownianus*), where these teeth are shorter, and the posterior one in each valve is split into several parts, without developing vertical ridges.

My specimens are of all sizes, but none of them reaches that of Sowerby's figure, which measures, from tip to tip of the wings, 115 mm., and from tip of anterior wing to lower posterior end of shell 115 mm.

Measurements.

| Length (Tips of Wings.) | Length (Anterior to lower posterior end.) | Height. | Diameter. | Figured. |
|---|---|---|---|---|
| 78 mm. | 65 mm. | 40 mm. | 25.5 mm. | |
| 94 " | 69 " | 43 " | 29 " | |
| 93 " | 78 " | 51 " | 33 " | Pl. XL, fig. 1. |

For obvious reasons (odd shape of shell) measurements could not be made here in the usual way. It also should be noted that the wings of the largest specimens

are slightly broken off, and also in the two others they are not quite perfect. The length from tip to tip of the wings is most nearly parallel to the hinge-line. The height is measured vertically to the hinge-line, from the beaks to the lower margin.

### 40. Prisodon castelnaudi (Hupé) (1857).

*Hyria castelnaudi* Hupé, 1857, p. 81, Pl. 16, fig. 1; Sowerby, XVII, 1869, Pl. 4, fig. 8.

*Prisodon castelnaudi* Simpson, 1900, p. 871; 1914, p. 1220.

*Prisodon obliquus castelnaudi* Von Ihering, 1910, p. 135, 137.

*Type-locality.*—Brazil.

*Other Localities.*—Rio Araguaya, Goyaz, Brazil (Von Ihering); Rio Chingu, Pará, Brazil (Von Ihering).

*New Locality.*—Rio Guaporé, near Rio São Simão, Matto Grosso, Brazil (J. D. Haseman coll., July 20, 1909). One young male with soft parts.

In addition, there is in the Carnegie Museum one larger specimen from the Hartman collection, labelled "River Amazon."

*Distribution.*—Positively known from the Amazon, two of the tributaries of its lower part in Goyaz and Pará, and from a tributary of the Madeira in Matto Grosso.

My specimens agree well with the account given by Simpson, but I should say that the hinge-teeth are not vertically ridged. The posterior pseudocardinal in either valve is cut up by deep fissures into accessory teeth, which are somewhat radiating. The lateral teeth are slightly rugose.

Von Ihering regards this as a variety of *P. obliquus* Schumacher (= *avicularis* Lamarck), and this is quite possible.

*Anatomy.*—A young specimen with soft parts is at hand, probably a male, since no marsupial structure can be seen.

Soft parts like those of *Hyria*. The palpi are slightly broader, and their lower margins more curved. The anterior end of the inner gill is immediately behind the palpi. Shape and structure of the gills normal.

## Subfamily Mutelinæ (See above, p. 457).

### *General Remarks.*

Shells of various shapes, subelliptical, subovate, subtrapezoidal, or more or less rounded. Beak-sculpture absent, only in one case have subconcentric bars been observed, which, however, may not be homologous to the real beak-sculpture of other *Naiades*.

Hinge rarely with teeth, which, when present, are much reduced and consist only of pseudocardinals or irregular teeth. Real laterals are never present.

Muscle-scars on inside of shell rather variable. Generally the anterior retractor-scar is united with the adductor-scar, forming an upper continuation of it (thus differing from the normal condition seen in the *Hyriinæ*). But in some cases the retractor-scar is partially or entirely isolated. Anterior protractor-scar quite variable, isolated from adductor-scar or contiguous with it, or even confluent with it. The posterior scars are rather uniform, agreeing with the *Hyriinæ*, the retractor-scar forming an upper process of the adductor-scar. Only in one case (*Anodontites ensiformis*), are these two scars widely separated. Dorsal muscle-scars mostly absent; if (rarely) present, only one may be found, or (in *Leila*) a row of them. (In the *Hyriinæ* several are always present.)

The pallial line is mostly simple and parallel to the margin; but in one genus (*Leila*) it forms a shallow sinus posteriorly. This undoubtedly is connected with the closing of the branchial opening in front, but unfortunately no soft parts of this genus are at hand, so that particulars cannot be given. Very often the prismatic border on the inside of the margin of the shell is unusually wide.

The ligamental sinus is comparatively large, larger than in the *Hyriinæ*; it may be broad and deep, but not sharply triangular (*Iheringella*), or deep and sharply triangular (in the other genera). In *Mycetopoda* it is shallow, but with a sharp lower angle.

As to the characters of the soft parts see above (p. 457). But it is well to point out here that the chief features in which this subfamily differs from the *Hyriinæ* are found in the structure of the gills (text-fig. 3, *i*, *o*, p. 458) which have well developed, solid septa, moderately closely set, running parallel to the gill-filaments (Pl. XLVII, figs. 3, 4). In the female (Pl. XLVII, figs. 3*b*, 4*b*; text-fig. 3*i*, p. 458), the septa of the marsupial inner gill are stronger, but not distinctly more crowded than in the non-marsupial gills, and have close to the outer lamina (primary limb) a ridge on each side, projecting into the lumen of the water canal, incompletely dividing the latter into two compartments (Pl. XLVIII, figs. 6, 7*b*, 8). The inner compartment, towards the inner lamina, assumes, when charged, the function of an ovisac, containing the eggs or embryos (Pl. XLVIII, fig. 7*b*), which do not stick closely together, and this compartment expands to a certain degree, the corresponding section of the septa stretching out, while the outer compartment (close to the other lamina) retains its shape, and does not contain eggs, thus apparently serving as a secondary water-tube.

The size of the eggs is small, 0.07 to 0.09 mm. According to Von Ihering the

larval form is a *lasidium* (Size: 0.10 mm). It is a very singular circumstance that I have not been able to find lasidia (or any other form of mature larvæ) in my material, although a good many gravid females of various species and genera are at hand.

## The Genera of the South American Mutelinæ.

*Mutelinæ* are found in South America and in Africa. Unfortunately, among the African forms, the anatomy of *Spatha* (including the subgenus *Aspatharia*) is alone known (Ortmann, 1910, p. 39; 1918, p. 75); but this genus differs from most South American *Mutelinæ* (*Fossula*, *Monocondylæa*, *Anodontites*) by the fact that the anal opening is closed above, without forming a supra-anal opening. In the South American genera this opening is open and not at all closed, with one exception, *Mycetopoda*, where about the upper half of the anal is closed. In addition, in *Spatha*, the inner gill is free from the abdominal sac, while in the South American genera it is connected with it. All other characters are similar. Thus, although closely allied to *Spatha*, the South American genera form a group by themselves, and the similarity of *Mycetopoda* to *Spatha* in the anal opening apparently indicates only parallelism of development, not genetic relationship.

It is hard to say which group is more primitive, since of the two differing characters, the one (anal opening) is more primitive in the American forms, the other (inner lamina of inner gill) more primitive in the African *Spatha*. The latter again is rather advanced in the shell, having no hinge-teeth, a condition which is also found in most South American Mutelinæ, but not in all, for *Iheringella*, *Fossula*, and *Monocondylæa* have at least pseudocardinals.

There is no question that among the South American forms, these genera with hinge-teeth should be regarded as more primitive. But a confirmation of this cannot be found in the anatomy, the latter being alike in all of them. Possibly the anatomy of *Iheringella* might furnish some enlightenment, but of this genus the soft parts have never been observed.

The structure of the hinge might be expected to furnish evidence of the connection of the *Mutelinæ* with the *Hyriinæ*. The very fact that there are genera among the *Mutelinæ* with hinge-teeth, indicates that the typical South American forms (of the *Anodontites*-type) are derived from forms with hinge-teeth. But the structure of these hinge-teeth is rather peculiar. They are always in a rudimentary condition, the laterals being missing, and the other teeth corresponding to the pseudocardinals cannot be positively homologized with the pseudocardinals of the *Hyriinæ*. Yet we are to assume on account of the many anatomical points

in common with the *Hyriinæ* that the *Mutelinæ* are related to, and probably descended from, the latter; but connecting links which undoubtedly stand between these two subfamilies are as yet unknown, and only the presence among the *Mutelinæ* of forms with hinge-teeth suggests that there once was a closer connection with the *Hyriinæ*. According to our present knowledge, the two subfamilies are undoubtedly allied; but they are very sharply separated by anatomical as well as shell-characters, and it is impossible to form an appropriate idea of their genetic connection.

Simpson (1914, p. 1384 *et seq.*), in his family *Mutelidæ*, admits six South American genera: *Monocondylæa, Iheringella, Fossula, Leila, Anodontites,* and *Mycetopoda*. These are easily distinguished by shell-characters, which are tabulated in the following key.

Key to the South American genera of Mutelinæ.

$a_1$. Hinge with more or less developed pseudocardinal teeth. Lunula short or almost absent, not much produced in front of the beaks.

- $b_1$. Hinge-plate rather broad, with oblique, compressed or tubercular, alternating pseudocardinals, two in each valve, the most anterior in the left valve. . . . . . . . . . . . . . . . . . . . . . . . . . . *Iheringella.*
- $b_2$. Hinge-plate narrow, with the pseudocardinals stumpy, squarish, or depressed, left valve never with two distinct pseudocardinals.
  - $c_1$. Left valve with one, right with two stumpy, or squarish, pseudocardinals, which alternate, the most anterior one being in the right valve. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Fossula.*
  - $c_2$. Either valve with only one pseudocardinal, which is generally depressed (spoon-shaped), that of the left valve being the most anterior. . . . . . . . . . . . . . . . . . . . . . . . . . *Monocondylæa.*

$a_2$. Hinge without any pseudocardinal-teeth. Lunula elongated and much produced in front of the beaks, forming a kind of anterior ligament.

- $b_1$. Pallial line without a sinus behind.
  - $c_1$. Shell rounded, subovate, or subtrapezoidal. Valves closed or somewhat gaping (when the shell is elongated, the valves are closed). Anal opening entirely open. Branchial opening not closed in front. Foot normal. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Anodontites.*
  - $c_2$. Shell elongated, gaping in front. Anal opening closed above. Branchial opening said to be closed in front (this is doubtful). Foot very long, developed at its distal end into a sort of button. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Mycetopoda.*
- $b_2$. Pallial line with a sinus behind. Shell large, subovate, winged. Valves gaping. Branchial opening said to be closed in front. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Leila.*

With regard to the genetic connections of these genera, it is clear that we are to regard the first three as the more primitive forms, and, judging from the shell, *Iheringella* appears to be the most primitive, having the most complete hinge. There is no doubt that of the others *Anodontites* is the simplest, but its connection with the first three is obscure, since the shell-characters do not connect it more closely with any one of them. Both *Mycetopoda* and *Leila* seem to have descended

from *Anodontites,* the former being characterized by a specialisation of the foot; the latter by a specialisation of the branchial opening. *Mycetopoda* is also peculiar in having the anal opening closed above. We can express this in the following diagram:

Mycetopoda Leila

Anodontites

?

Iheringella, Fossula, Monocondylæa

The anatomy furnishes no additional help for the understanding of the phylogeny of these genera, except the points mentioned in the key. In fact, the anatomy is so disappointingly similar in all of them, that it is practically useless. Only in *Mycetopoda* and *Leila* have we been able to recognize higher stages of development in the anatomy, but it should be mentioned that I have not been able to verify this fact in *Leila,* of which I have not had the opportunity to examine soft parts. The same is true of *Iheringella.* Of *Fossula, Monocondylæa,* and *Anodontites,* I know the anatomy very well, but no differentiations whatever have been observed.

## The Species of South American Mutelinæ.

### Genus Iheringella Pilsbry (1893).

Pilsbry, 1893, p. 30; Simpson, 1914, p. 1392.

Characterized by rather broad hinge-plate and compressed or stumpy pseudocardinals, two in the right and two in the left valve, the anterior pseudocardinal of the left valve the most anterior of all hinge-teeth. These teeth, however, are rather variable.

This genus approaches the *Hyriinæ* most closely in its hinge, but in the details of its structure it is very different from any of them. It belongs to the La Plata-drainage, and possibly also to that of the upper Amazon.

### 41. Iheringella balzani (Von Ihering) (1893).

*Plagiodon balzani* Von Ihering, 1893, p. 69, Pl. 3, fig. 2.

*Iheringella balzani* Simpson, 1900, p. 914; 1914, p. 1359.

*Type-locality.*—Rio Paraguay, near mouth of the Rio Apa, Matto Grosso, Brazil.

*New Locality.*—Rio Paraguay, San Luis de Caceres, Matto Grosso, Brazil (J. D. Haseman coll., May 25, 1909). Two complete shells and one left valve.

*Distribution.*—Known only from the upper Rio Paraguay. Simpson also gives "San Paulo, Brazil," but I do not know upon what authority.

My specimens agree well with Von Ihering's description and figure, but they are larger. Von Ihering says that the color of the epidermis is dark olive or blackish. In our largest and smallest (half-shell) specimens the surface is much corroded and worn, and brownish green. In the specimen of medium size, which is better preserved, it is yellowish green, with a few scattered dark green spots upon the disk, becoming more frequent near the beaks. Upon the posterior ridge, there are a few fine, interrupted, dark green rays, and a broader ray runs over the posterior slope.

In the two smaller specimens, the structure of the hinge corresponds entirely with Von Ihering's description. In the largest, however, the anterior tooth of the left valve is obsolete, and so is the groove between the two teeth. The posterior tooth is broad and slightly bifid. In consequence of this the groove of the right valve is also broader and has a radial ridge in its bottom, and the anterior tooth of the right valve is very small. I consider this an abnormality. In this specimen there apparently is only one (bifid) tooth in the left valve, and two small ones in the right, with an accessory ridge in the groove between them.

In all three of my specimens, the ligamental sinus is wider and shallower than figured by Von Ihering, which may be due to their greater age.

MEASUREMENTS.

| Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|
| 34 mm. | 26 mm. = 76 pr. ct. of L. | 16 mm. = 47 pr. ct. of L. | at 9 mm. = 26 pr. ct. of L. |
| 40 " | 31 " = 78 " | 21 " = 53 " | 11 " = 28 " |
| 46 " | 35 " = 76 " | 23 " = 50 " | 12 " = 26 " |
| 32 " | 27 " = 84 " | 17 " = 53 " | = 30 " (Von Ihering, beaks from figure) |

The measurements given by Simpson (1914, p. 1395) are entirely wrong, and are those of *Fossula balzani* Von Ihering.

## Genus Fossula Lea (1870).

Lea, Syn. 1870, p. 72, foot-note 1; Von Ihering, 1893, p. 62; Simpson, 1900, p. 914; 1914, p. 1396.

The distinguishing character of this genus is found in the hinge-teeth, of which there are two in the right valve, enclosing between them one in the left valve. The hinge-plate is narrow, the teeth are stumpy (not vertically compressed or spoon-like as in *Monocondylæa*). There are traces of additional teeth and irregularities of the hinge, which, however, are variable. The "cement processes" described by Von Ihering are not always present.

A key to the three known species has been given by Von Ihering (1910, p. 115). Two of the species are from the Paraná-drainage, and one is from a coastal river in eastern Brazil, the Rio Paraguassú in Bahia.

42. Fossula fossiculifera (D'Orbigny) (1835).

*Section of gills:* Plate XLVIII, fig. 6.

*Monocondylœa fossiculifera* D'Orbigny, 1843, p. 614, Pl. 80, figs. 5–7.
*Unio fossiculiferus* Sowerby, XVI, 1868, Pl. 96, fig. 521.
*Fossula fossiculifera* Von Ihering, 1893, p. 64, Pl. 3, fig. 2; Nehring, 1893, p. 164; Simpson, 1900, p. 914; Von Ihering, 1910, p. 115; Simpson, 1914, p. 1396.

*Type-locality.*—Rio Paraná, Iribucua, above Corrientes, Argentina.

*Other Localities.*—Rio Paraná and lower Rio Tieté, São Paulo, Brazil (Von Ihering); Rio Piracicaba, Piracicaba, São Paulo, Brazil (Von Ihering) (Nehring).

*Localities Represented in the Carnegie Museum.*—Rio Piracicaba, Piracicaba, São Paulo, Brazil (Von Ihering donor). One specimen. Rio Tieté, Salto de Avanhandava, São Paulo, Brazil (J. D. Haseman coll., September 15, 1908). One specimen. Rio Tieté, Salto das Cruzes, São Paulo, Brazil (J. D. Haseman coll., September 22, 1908). One female with soft parts. Rio Tieté, Itapura, São Paulo, Brazil (J. D. Haseman coll., September 28, 1908). One female with soft parts.

*Distribution.*—Rio Paraná and its tributaries from Argentina to São Paulo, Brazil.

This species has been well figured by D'Orbigny and Von Ihering, and has been well described by the latter. No further details need to be supplied.

Measurements.

| | Sex. | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|---|
| Salto das Cruzes | ♀ | 56 mm. | 44 mm. =78 pr. ct. of L. | 27 mm. =48 pr. ct. of L. | at 21 mm. =38 pr. ct. of L. |
| Itapura | ♀ | 74 " | 63 " =85 " | 38 " =51 " | 23 " =31 " |
| Avanhandava | | 79 " | 62 " =78 " | 38 " =48 " | 25 " =32 " |
| Piracicaba | | 79 " | 64 " =81 " | 39 " =49 " | 26 " =33 " |
| (Von Ihering) | | 74 " | 63 " =85 " | 38 " =51 " | 24 " =32 " |

According to Von Ihering the height varies from 80 to 85 pr. ct., while in D'Orbigny's specimen it is 77 pr. ct.

*Anatomy.*—Partially described by Von Ihering (1893, p. 65) for the male. I am able to supplement this from two barren females at hand.

Anal opening entirely open, very large, with smooth inner edge, very faintly crenulated in the lower part, separated by a solid mantle-connection from the

branchial opening, which has small papillæ on the inner edge. These papillæ extend rather far forward, decreasing in size, and disappearing gradually. Palpi moderately large and broad, semicircular, posteriorly with a short truncation forming the posterior margins, which are not connected.

Gills rather wide, the inner the wider, chiefly anteriorly, its anterior end immediately behind the palpi; that of the outer gill at the highest point of the attachment-line of the mantle, so that the lower margin of the outer gill is curved, the gill narrowing considerably in front, while the inner is not much narrower in front, and has the lower margin rather straight. Inner lamina of inner gill entirely connected with abdominal sac. Both gills with well developed, strong septa. The non-marsupial outer gill has the septa alternately stronger and thinner, but the alternation is irregular. The *marsupium* is in the inner gill of the female. Here the septa are more uniform and very strong, but hardly more closely set than in the non-marsupial gill. Where the septa are inserted at the outer limb, they have a swelling on each side, which forms a vertical ridge projecting into the lumen of the water-tubes (See Pl. XLVIII, fig. 6). This ridge is less developed in my younger female, yet perfectly distinct. The septa near the anterior and posterior end of the inner gill do not have marsupial structure, but the marsupial part is very large, occupying nearly the whole gill.

### Genus Monocondylæa D'Orbigny (1835).

D'Orbigny, 1835, p. 37; 1843, p. 611; Simpson, 1900, p. 910; 1914, p. 1384.

Normally each valve has only one pseudocardinal tooth, that of the left valve being more anterior. The teeth are more or less depressed (spoon-shaped). Traces of additional teeth may be present, but they are insignificant and variable.

A key for the species has been given by Simpson (1914, p. 1385), which, however, is artificial and unsatisfactory, and the essential characters apparently have been misunderstood. Moreover, I believe that *M. guarayana* D'Orbigny (1843, Pl. 68, figs. 4–7) does not belong here, but probably to *Iheringella.*

The specimens before me all have a cloth-like epidermis, with crowded, irregular and anastomosing, concentric lines, which are lamellarly elevated. But very often these fine lamellæ are abraded, so that the surface appears smooth. Nevertheless the lamellæ are generally preserved in some part of the shell, chiefly on the posterior slope and near the margins, and, even when abraded, they can be easily noticed as fine lines. The species at hand, which have been treated by Simpson have been called "smooth or lightly concentrically striate." He distinguishes them according to the outline, orbicular, obovate, elliptical, subrhomboidal, or subquadrate, but it is extremely hard to draw a line between these terms.

The following key is intended only for the distinction of the forms at hand.

KEY TO THE SPECIES OF MONOCONDYLÆA.

$a_1$. Shell small, or of medium size (at the utmost 50 to 60 mm. long). Lamellar striæ of epidermis well developed, but sometimes abraded. Color of epidermis greenish black or brown.

- $b_1$. Shell more or less oblique, subtrapezoidal, or angularly suborbicular, with a well developed posterior upper angle, high behind, narrower in front. Color of epidermis greenish black. Prismatic zone on inside of margin of unequal width, very wide along anterior portion of lower margin.
  - $c_1$. Shell angularly suborbicular, rather high and short, height about 80 pr. ct. of length. Sides of disk not flattened.
    - $d_1$. Shell compressed, diameter 50 pr. ct. or less of length. Beaks not much elevated. *M. lentiformis.*
    - $d_2$. Shell more swollen, diameter 58 to 59 pr. ct. of length. Beaks more inflated and elevated.................................................. *M. paraguayana.*
  - $c_2$. Shell subtrapezoidal, more elongated, height about 70 pr. ct. of length. Sides of disk more or less flattened.
    - $d_1$. Shell more swollen, beaks more prominent, hinge-line rather strongly incurved under the beaks.................................................. *M. minuana.*
    - $d_2$. Shell less swollen, beaks less prominent, hinge-line less incurved under the beaks. *M. minuana parchappi.*
- $b_2$. Shell very little, or not at all oblique, subovate or subelliptical in outline, with the posterior upper angle rounded and poorly developed. Obesity of shell very great, and beaks much swollen and inflated. Color of epidermis brown. Prismatic zone on inside of margin narrow and of nearly uniform width.................................................. *M. obesa.*

$a_2$. Shell large (about 100 mm. long). Lamellar striæ of epidermis poorly developed upon the disk, distinct only near the margins. Color of epidermis from yellowish olive upon the disk and toward the beaks to dark brown toward the margins.................................... *M. hollandi.*

The species of this genus cover a rather large range in South America being found all over the La Plata-drainage, in the Amazon-drainage in Bolivia and Brazil, in the Rio San Francisco in eastern Brazil, and also in coastal streams in southern Brazil (Rio Grande do Sul).

### 43. MONOCONDYLÆA LENTIFORMIS Lea (1866).

*Anatomy of gills:* Plate XLVII, fig. 3.

*Monocondylæa lentiformis* LEA, Obs., XII, 1869, Pl. 36, fig. 86; PILSBRY & RUSH, 1896, p. 81; SIMPSON, 1900, p. 912; 1914, p. 1392; CORSI, 1901, p. 452; HAAS, 1916, pp. 25, 54.

*Aplodon lentiformis* VON IHERING, 1893, p. 67; NEHRING, 1893, p. 164.

*Type-locality.*—South America.

*Other Localities.*—Rio Piracicaba, Piracicaba, São Paulo, Brazil (Von Ihering) (Nehring); Rio Uruguay, Salto Oriental, Uruguay (Haas); Rio de la Plata, Colonia, Uruguay (Pilsbry & Rush).

*New Localities.*—Rio Uruguay (in mud), Uruguayana, Rio Grande do Sul, Brazil (J. D. Haseman coll., February 5, 1909). Four specimens with soft parts, males and females. Rio Cacequy, Cacequy, Rio Grande do Sul, Brazil (tributary to Rio Ibicuhy, to Uruguay) (J. D. Haseman coll., February 2, 1909). Two specimens with soft parts, male and female. Rio Jacuhy, Cachoeira, Rio Grande do Sul, Brazil (tributary to Rio Guahyba) (J. D. Haseman coll., January 26, 1909). Two specimens.

*Distribution.*—Known from the Rio de la Plata, and up the Uruguay, and from the upper Paraná drainage in São Paulo. The species has not been found in the lower and middle Paraná, although it should be expected there. In addition it is found, as our specimens show, in the drainage of a coastal stream in Rio Grande do Sul (Guahyba). This is a remarkable fact, but it should be borne in mind that the head-waters of the Ibicuhy (Uruguay drainage) and those of the Jacuhy (Guahyba-drainage) closely interlock, and that stream piracy in this region is quite probable.

*Characters of the Shell.*—Shell rather small (maximum length 44 mm.), moderately thick, outline more or less subcircular or subpolygonal. Height 77 to 88 pr. ct. of length. Valves very little gaping in front, sometimes almost closed. Dorsal margin straight behind the beaks, or gently convex, much lower in front of the beaks, and straight here or even somewhat concave, passing in a curve or a very blunt angle into the anterior margin. Posteriorly the dorsal margin passes in a distinct, or indistinct, blunt angle into the posterior margin. The latter descends obliquely, and is straight, rarely slightly convex or concave. It passes in a curve into the posterior part of the lower margin, forming the blunt posterior end of the shell. The lower margin is curved, the strongest part of the curve and the lowest point of the shell is situated at 54 to 60 pr. ct. of the length from anterior end, and is thus immediately behind the middle. From this point the lower margin curves up rather strongly in the posterior part. In the anterior portion it is very gently curved, or almost straight, and finally curves up sharply into the anterior margin. Thus the anterior end of the shell appears narrower than the posterior, and the shell has the shape of an irregular pentagon.

Valves very gently convex, rather compressed, greatest convexity behind the middle of the shell, without a distinct posterior ridge. Sides not flattened. Toward the anterior and posterior end the shell is somewhat compressed. Diameter 41 to 51 pr. ct. of the length. Beaks little swollen, and very little prominent, located at 31 to 39 pr. ct. of the length. Lunula narrow and short.

Epidermis dull, not shining, with very crowded, irregular concentric lines, which form fine lamellæ, and give a cloth-like appearance to the surface. But

these lamellæ may be worn off in part, and the surface may be smoother. No distinct radial sculpture is visible, but there may be a trace of a radial rib upon the posterior slope. Color of epidermis blackish green, without color-markings, except traces of one or two dark rays upon the posterior slope.

Hinge-line straight behind the beaks. In front it is curved down more or less suddenly, and carries a single pseudocardinal tooth in each valve. The tooth of the left valve stands in front of, and somewhat below, that of the right valve. Both teeth are vertically depressed, somewhat spoon-shaped, and project under the edge of the opposing valves into corresponding shallow grooves. Ligamental sinus triangular, not deeper than wide; its anterior margin more or less oblique to the hinge-line.

Nacre very iridescent, whitish, but generally with salmon, pink, or pale purple stains, chiefly in the cavity of the shell. Irregular radiating lines present, but only near the margin. Nacreless (prismatic) zone of irregular width, narrow behind, suddenly increasing in width at the lower point of the lower margin, and remaining wide to near the anterior margin. Greatest width of this zone over half the distance of mantle-line from margin. Color of nacreless zone dull olive, grayish, or grayish red.

Cavity of shell and beaks shallow. Anterior adductor-scar well marked, ovate. Anterior retractor-scar small, but distinct, separated from or connected with the adductor-scar, lying in the left valve on the base of the pseudocardinal tooth. Anterior protractor-scar connected with adductor-scar. Posterior adductor-scar faint, ovate; posterior retractor-scar forming a triangular upper projection of adductor-scar. No dorsal scars. Pallial line subconcentric to the margin.

MEASUREMENTS.

| Localities. | No. | Sex. | Length. | Height. | Diameter. | Beaks. | Greatest Height. |
|---|---|---|---|---|---|---|---|
| Cachoeira . . . | 1 | ? | 34 mm. | 27 mm. =79% of L. | 14 mm. =41% of L. | at 11 mm. =32% of L. | at 20.5 mm. =60% of L. |
| Uruguayana . | 1 | ♂ | 38 " | 31.5 " =83 " | 18 " =47 " | 15 " =39 " | 22 " =58 " |
| Cacequy . . . . | 2 | ♂ | 39 " | 30 " =77 " | 16 " =41 " | 13 " =33 " | 23 " =59 " |
| Do. . . . . | 1 | ♀ | 39 " | 31 " =79 " | 18 " =46 " | 13 " =33 " | 23 " =59 " |
| Uruguayana . | 3 | ♀ | 39 " | 34.5 " =88 " | 19.5 " =50 " | 14 " =36 " | 21 " =54 " |
| Do. . | 2 | ♂ | 41 " | 33.5 " =82 " | 18 " =44 " | 13 " =32 " | 24 " =59 " |
| Do. . | 4 | ♀ | 42 " | 36 " =86 " | 20.5 " =49 " | 15 " =36 " | 23 " =55 " |
| Cachoeira . . . | 3 | ? | 43 " | 34 " =79 " | 19 " =44 " | 13.5 " =31 " | 25 " =58 " |

*Remarks.*—These measurements agree well with those given by Von Ihering and Nehring. According to Von Ihering the height ranges from 80 to 84 pr. ct. of length, the diameter from 46 to 51 pr. ct., while Nehring gives for the height 77 to 82 pr. ct., the diameter 46 to 49 pr. ct. Lea's original figure shows, according to Von Ihering, 80 pr. ct. for the height, and 44 pr. ct. for the diameter. The speci-

mens from Cachoeira (Guahyba-drainage) entirely correspond with the others in these respects, and I cannot distinguish them by any other characters.

The chief features of this species are the subcircular, or rather rounded-pentagonal outline, the great height of the shell, the location of the greatest height close behind the middle of the shell, and the flatness of the valves. If properly placed, with the ligament horizontal, it is seen that the shell is distinctly oblique, and that the anterior end is narrower.

*Anatomy.*—Three males and three barren females are at hand.

Von Ihering (1893, p. 69) has mentioned a number of anatomical characters, but his account is not complete.

Anal opening entirely open, large, its inner edge with distinct crenulations in the lower part, otherwise smooth, separated from the branchial opening by a mantle-connection. Inner edge of branchial opening with distinct, but small, papillæ. Palpi moderately large, semicircular, briefly truncated behind, the posterior margins not connected.

Gills (Pl. XLVII, figs. 3*a*, *b*) of medium width, the inner the wider, chiefly in front; the outer narrowing anteriorly, its anterior end near the highest point of the mantle-attachment-line. The inner gill very little narrowed in front, beginning immediately behind the palpi. Inner lamina of inner gill entirely connected with abdominal sac.

Gills with well developed septa. Those of the male (Pl. XLVII, fig. 3*a*) and of the outer gill of the female alternately stronger and weaker. This alternation, however, is not very distinct, and is chiefly seen in the middle of the gill. In the female (Pl. XLVII, fig. 3*b*) the inner gill is marsupial, with the septa more uniform and stronger, but hardly more crowded. At the point of union with the outer lamina, the usual swelling is present, indicating the ridges projecting into the water tubes. The most anterior and most posterior extremity of this gill has not the marsupial structure, but the marsupium occupies nearly the whole gill.

In the specimen sectioned, the swellings of the septa are located nearly in the middle. However, the part of the septa from the swelling toward the inner lamina is thicker, and has more strongly developed epithelium, indicating that this is the part which stretches out, when gravid. The condition seen in this specimen undoubtedly is due in part to its barren character, in part to the state of preservation.

### 44. Monocondylæa paraguayana D'Orbigny (1835).

*Monocondylæa paraguayana* D'Orbigny, 1843, p. 612, Pl. 70, figs. 5–7; Simpson, 1900, p. 911 (in part); 1914, p. 1387.

*Unio paraguayana* Sowerby, XVI, 1866, Pl. 52, fig. 273.

*Type-locality.*—Rio Paraná, Itaty, near Corrientes, Argentina.

*Other Locality.*—Rio Batel, Province Corrientes, Argentina.

*New Locality.*—Rio Uruguay (in mud), Uruguayana, Rio Grande do Sul, Brazil (J. D. Haseman coll., February 5, 1909). One female with soft parts.

*Distribution.*—Known from Rio Paraná and its tributary, the Rio Batel in Argentina, and from the Rio Uruguay.

*Characters of Shell.*—Shell moderately thick, and of medium size (maximum length 59 mm.). Outline briefly subtrapezoidal, rather high (height 77 to 81 pr. ct. of length), distinctly oblique, but approaching an angularly suborbicular shape. Valves in front gaping very little. Dorsal margin behind the beaks slightly convex, much lower in front of the beaks, where it is distinctly concave, and passes into the anterior margin in a blunt, but distinct, angle. Posteriorly the dorsal margin passes into the posterior margin in a rather sharp curve, forming a blunt angle. Posterior margin descending obliquely, but very steeply, almost straight, and curving into the lower margin, forming with it the broadly rounded posterior end of the shell. Lower margin very little curved in the anterior part and sloping upward; posteriorly more distinctly curved. Its lowest point (and the greatest height of the shell) at about 57 pr. ct. of the shell (60 pr. ct. according to D'Orbigny's figure). In front, the lower margin curves up into the anterior margin. The anterior end of the shell is narrower than the posterior, thus producing the oblique shape.

Valves very convex, chiefly so in the anterior part and backward to the posterior ridge, and without any flattening upon the sides. Behind the posterior ridge the shell is strongly compressed, so that the posterior slope and the upper posterior angle appear almost alate. The most extreme anterior end of the shell is also slightly compressed. Diameter 59 pr. ct. of the length (58 pr. ct. according to D'Orbigny). Beaks inflated and swollen, incurved, projecting over the lunula, but only slightly elevated above the posterior part of the upper margin. Lunula distinct, short, triangular, about half as wide as long.

Epidermis dull, with crowded, irregular, concentric lines, which frequently become lamellar: probably, where not lamellar, they are worn off, and originally the whole epidermis was cloth-like. No radial sculpture visible. A radial rib upon the posterior slope, but rather indistinct (much less distinct than in D'Or-

bigny's figure, and hardly forming a point and an emargination on the posterior margin, as in this figure). Color of epidermis dark grayish green to blackish, the grayish green shade due to the preservation of the lamellæ. A rather distinct black radial ray upon the rib of the posterior slope, and faint traces of additional rays in front of and behind it.

Hinge gently curved behind the beaks. Under the beaks it is sharply curved down, and in front of them it curves up again, thus becoming concave. Each valve has a single pseudocardinal tooth of the typical shape; that of the left valve anterior to, and a little below, that of the right; both triangular and depressed, and projecting under the margin of the opposite valve, where they fit into shallow grooves. Ligamental sinus triangular, wider than deep, its anterior margin oblique to the hinge-line.

Nacre very iridescent, whitish, with a faint salmon blush in the cavity of the shell, and purple and greenish reflections toward the margins. Irregular radiating lines are present toward the margin. Prismatic zone of unequal width, rather narrow behind, widening quite suddenly at the lowest point of the shell, and remaining wide along the anterior ascending part of the lower margin, narrowing again at the anterior end. Color of prismatic zone grayish green.

Cavity of shell and beaks moderate. Anterior adductor-scar deep, elliptical. Anterior retractor-scar small, at the upper end of the adductor-scar, distinctly isolated in left valve, narrowly connected with it in the right. Anterior protractor-scar small and united with adductor-scar. Posterior adductor-scar faint, subovate, with an upper triangular projection formed by the posterior retractor-scar. No dorsal scars. Pallial line subconcentric to the margin.

MEASUREMENTS.

| Sex. | Length. | Height. | Diameter. | Beaks. | Greatest Height. |
|---|---|---|---|---|---|
| ♀ | 53 mm. | 43 mm. = 81 pr. ct. of L. | 31 mm. = 59 pr. ct. of L. | at 16 mm. = 30 pr. ct. of L. | at 30 mm. = 57 pr. ct. of L. |

*Remarks.*—In general outline this species is much like *M. lentiformis*, as is shown by the proportion of height to length and the location of the greatest height of the shell. It markedly differs, however, in the much more swollen shell (diameter 59 pr. ct. as against 41 to 51 pr. ct. in *lentiformis*), and the more inflated beaks. In consequence of the very convex disk, the posterior slope appears much more compressed and alate.

*Anatomy.*—The specimen at hand for examination is a barren female.

The structure is absolutely identical with that of *M. lentiformis*, and nothing is to be added, except that the crenulations of the lower part of the anal opening

are less distinct, and that the palpi appear a little larger, with longer posterior margins, which are connected at the base. These differences, however, may be due to preservation.

The septa of the inner marsupial gill also have the characteristic swelling, not so close to their insertion with the outer lamina, but more toward the middle of the septum.

### 45. Monocondylæa minuana D'Orbigny (1835).

*Section of gills:* Plate XLVIII, fig. 7.

*Monocondylæa minuana* D'Orbigny, 1843, p. 612, Pl. 70, figs. 8–10; Corsi, 1901, p. 452, fig. 34; Simpson, 1914, p. 1388.

*Unio minuanus* Sowerby, XVI, 1868, Pl. 91, fig. 497.

*Monocondylæa pazii* Lea, Obs., XII, 1869, Pl. 36, fig. 88; Pilsbry & Rush, 1896, p. 81.

*Monocondylæa paraguayana* Simpson, 1900, p. 911 (*pro parte*).

*Type-locality.*—Canelon Grande and del Rosario, Banda Oriental, Uruguay (Arroyo Grande flows North to Rio Negro; Arroyo Rosario flows South to Rio de la Plata).

*Other Localities.*—Arroyo de las Vacas, Uruguay (Corsi); Rio de la Plata, Colonia, Uruguay (Pilsbry & Rush, *pazii*).

*New Localities.*—Rio Uruguay, (in mud) Uruguayana, Rio Grande do Sul, Brazil (J. D. Haseman coll., February 5, 1909). Five specimens with soft parts, males and females. Rio Jacuhy, Cachoeira, Rio Grande do Sul, Brazil (J. D. Haseman coll., January 26, 1909). Five specimens with soft parts, males and females.

*Distribution.*—Rio de la Plata and its tributaries in the Banda Oriental; Rio Uruguay and Rio Negro drainages; and in Guahyba drainage in Rio Grande do Sul.

*Characters of the Shell.*—Shell moderately thick, rather small (maximum length 55 mm.). Outline subtrapezoidal, strongly oblique, rather elongated (height 67 to 72 pr. ct. of length). Valves very slightly gaping at anterior end. Dorsal margin straight behind the beaks, or gently convex, much lower in front of beaks, where it may be straight or somewhat concave, forming with the anterior margin a more or less distinct, obtuse angle. Posteriorly the dorsal margin passes into the posterior margin in a more or less distinctly obtuse angle. Posterior margin obliquely descending, straight, or gently curved, passing into the lower margin in a strong curve, which forms the rounded lower posterior end of the shell, not much elevated above the base-line. Lower margin in its middle and anterior part

very gently curved or almost straight, sloping upward; the lowest point located rather far backward (at 66 to 77 pr. ct. of the length). Anteriorly and posteriorly the lower margin curves up into the anterior and posterior margins. Anterior end of shell markedly narrower than the posterior.

Valves very convex, but distinctly flattened upon the sides of the disk, which flattening may even become a shallow depression. Greatest convexity in front and behind the flat area, and the posterior convexity, forming the rounded posterior ridge, is the stronger. Posterior slope somewhat compressed and elevated, but hardly alate. At its anterior end the shell is also a little compressed. Diameter 50 to 56 pr. ct. of length, but sometimes falling below 50 pr. ct., and such specimens approach the var. *parchappi*. Beaks more or less swollen, inflated, and incurved, prominent over the lunula, but only little elevated above the posterior part of the upper margin. Lunula distinct, short, elongated triangular, variable, narrower in young, broader in old specimens, where it may be half as wide as long.

Epidermis dull, cloth-like. Fine and crowded, anastomosing, concentric striæ are elevated as fine lamellæ, but often they are abraded. No radial sculpture visible, and there is hardly a trace of a radial ridge upon the posterior slope. Color of epidermis dark grayish green, without any trace of color-markings, except occasionally a mere indication of a dark ray upon the posterior slope.

Hinge straight, or gently curved, in its posterior part. Under the beaks it curves down more or less suddenly, and then becomes straight again, or even somewhat concave. The curvature of the hinge-line is quite variable, and corresponds to the varying degree of the development of the beaks. Pseudocardinal teeth as in *M. paraguayana*. Ligamental sinus triangular, wider than deep, with its anterior margin oblique to the hinge-line.

Nacre very iridescent, whitish, with greenish and purplish tints, chiefly posteriorly. Irregular radiating lines present, but faint in old specimens. Prismatic zone of unequal width, rather narrow behind, suddently widening at the lower point of the lower margin, and remaining wide to near the anterior margin. However this widening is not so strongly pronounced as in *M. paraguayana*, and is also individually variable. Color of prismatic zone greenish gray.

Cavity of shell and beaks moderate. Anterior adductor-scar sharply and rather deeply impressed, subelliptical; anterior retractor-scar small, connected with, or separated from, adductor-scar; anterior protractor-scar connected with adductor-scar. Posterior adductor-scar distinct, but less strongly impressed; scar of the posterior retractor forming a short, triangular upper process of it, which, in a few specimens, is partly separated from it. No dorsal scars. Pallial line distinct, subconcentric to the margin.

MEASUREMENTS.

| Localities. | No. | Sex. | Length. | Height. | Diameter. | Beaks. | Greatest Height. |
|---|---|---|---|---|---|---|---|
| Uruguay-ana..... | 1 | ♂ | 24 mm. | 17 mm. =71% of L. | 12 mm. =50% of L. | at 9 mm. =38% of L. | at 18.5 mm. =77% of L. |
| Do. .. | 3 | ♀ | 35 " | 25 " =71 " | 17.5 " =50 " | 12 " =34 " | 25 " =71 " |
| Do. .. | 6 | ♀ | 39 " | 28 " =72 " | 22 " =56 " | 14 " =36 " | 27 " =69 " |
| Do. .. | 5 | ♂ | 41 " | 28 " =68 " | 21 " =51 " | 14 " =34 " | 27 " =66 " |
| Do. .. | 7 | ♂ | 48 " | 33 " =69 " | 24 " =50 " | 15 " =31 " | 33 " =69 " |
| Cachoeira.. | 1 | ♂ | 28 " | 19.5 " =70 " | 12.5 " =45 " | 9.5 " =34 " | 18.5 " =66 " |
| Do. .. | 2 | ♀ | 34.5 " | 23 " =67 " | 16.5 " =48 " | 11 " =32 " | 23 " =67 " |
| Do. .. | $x$ | ? | 36 " | 27 " =75 " | 16.5 " =46 " | 11 " =31 " | 25 " =69 " |
| Do. .. | 3 | ♀ | 43 " | 30 " =70 " | 22 " =51 " | 13 " =30 " | 29 " =67 " |
| Do. .. | 4 | ♀ | 44 " | 30.5 " =69 " | 21.5 " =49 " | 12 " =27 " | 29 " =66 " |

*Remarks.*—The measurements for *minuana* given by D'Orbigny in the text and those taken from his figures do not agree, but according to the latter the height is about 64 to 67 pr. ct. of length, and the diameter about 50 pr. ct. Our specimens from Cachoeira have, on the average, a smaller diameter (falling as low as 45 pr. ct.), and in this respect they are transitional toward the variety *parchappi*; but in other characters (beaks and hinge-line) they agree better with typical *minuana.*

*M. pazi* Lea is apparently the same species. Simpson unites it with *parchappi*, and it indeed approaches the latter in obesity, having a diameter of 46 pr. ct., (*parchappi* of D'Orbigny has 43 pr. ct.), but here again the beaks and the curvature of the hinge-line are more like *minuana*, and for this reason I place it here.

Just because such intergrades do exist, I regard *parchappi* as a variety of *minuana* (See below). Where the line between the two forms should be drawn remains doubtful, and naturally it could not be expected that there is a *sharp* line. I have named as *miuana* my specimens with the diameter of 45 pr. ct. and over, because their beaks and hinge-line are more like those of *minuana*, but this procedure possibly may require modification, when more material is studied.

*Anatomy.*—I have examined the soft parts of six males, and of five females. Two of the latter, collected February 5 (Uruguayana), were gravid.

Lea (Obs. XII, 1869, p. 273) has described the soft parts of *M. pazi*, and, as far as it goes, this description agrees with our specimens.

The structure of the soft parts is essentially like that of the foregoing species (*lentiformis* and *paraguayana*). It should be remarked that the palpi are rather large, with a somewhat longer posterior truncation, and the posterior margins are connected at the base. Anal opening practically smooth. Papillæ of the branchial opening very small.

In the gravid female the whole inner gill is charged, with exception of the outermost extremities. The swelling of the *marsupium* is very moderate, and in a cross-section (Pl. XLVIII, fig. 7*b*) it is seen that only the part of the septa, extend-

ing from the swellings, toward the inner lamina (secondary limb) stretch out, and that the egg-masses are located only in this part of the water-tubes, while the part toward the outer lamina (primary limb) does not contain eggs, and forms what should be called *secondary water-tubes*. In the sterile female the swelling of the septa (vertical ridges projecting into the water tubes) are located as usual. In the cross-section of the gills of the male (Pl. XLVIII, fig. 7*a*) it is seen, chiefly in the inner gill, that the alternation of stronger and weaker septa is due to the alternating presence or absence of a larger blood-vessel at the point where the septum connects with the primary limb. In the marsupial gill of the female this is obscured in the direct view by the development of the ridges, so that the septa appear more uniform.

The contents of the charged marsupium consist of small globular embryos in an early stage of development. No lasidia were seen. Von Ihering (1891, p. 480) mentions the eggs of *Aplodon pazi*. They are small, 0.075 mm. in diameter.

45*a*. Monocondylæa minuana parchappi (D'Orbigny) (1835).

*Monocondylæa parchappi* D'Orbigny, 1843, p. 615, Pl. 68, figs. 1–3; Simpson, 1900, p. 911; 1914, p. 1386; Haas, 1916, pp. 24, 54.

*Type-locality*.—Rio Paraná, Itaty, Province Corrientes, Argentina.

*Other Locality*.—Rio Uruguay, Salto Oriental, Uruguay (Haas).

*New Locality*.—Rio Jacuhy, Cachoeira, Rio Grande do Sul, Brazil (J. D. Haseman coll., January 26, 1909). One specimen, male with soft parts.

*Distribution*.—Rio Paraná and Rio Uruguay, and also Guahyba-drainage. The distribution resembles that of *M. minuana*.

D'Orbigny has already pointed out the close resemblance of this form to *M. minuana*, but gives as differentiating characters the greater compression of the shell, the less elevated and less incurved beaks, the absence of a lunula, and the rose-colored nacre. We may dismiss the last two characters as unimportant, since the lunula is variable and generally less developed in forms with lower beaks; and since reddish nacre is found as an individual variation in other species of *Monocondylæa*. But the greater compression of the shell and the feebler development of the beaks is striking. In D'Orbigny's figure, as well as in my specimen, the latter character is connected with a straighter hinge-line, which is much less incurved below the beaks.

We have seen that specimens of *minuana* sometimes approach *parchappi* in the less pronounced obesity. The same may be said of the inflation of the beaks and the curvature of the hinge-line. However, none of my specimens recorded as

*minuana* from Cachoeira have the beaks as low and the hinge-line as straight as the specimen placed under *parchappi*. But there is no question that they incline in this direction, and that beaks and hinge-line are quite variable in *minuana*. Thus these two forms should be regarded as varieties of one species, actually connected by intergrades.

MEASUREMENTS.

| Sex. | Length. | Height. | Diameter. | Beaks. | Greatest Height. |
|---|---|---|---|---|---|
| ♂ | 41 mm. | 29 mm. =71 pr. ct. of L. | 17 mm. =41 pr. ct. of L. | at 12 mm. =29 pr. ct. of L. | at 26 mm. =63 pr. ct. of L. |

According to D'Orbigny, *parchappi* has a height of 64 pr. ct. and a diameter of 43 pr. ct., so that length and diameter are a little greater than in my specimen.

*Anatomy.*—The specimen at hand is a male according to the soft parts. The structure is absolutely identical with that of the males of *M. minuana*.

46. MONOCONDYLÆA OBESA Ortmann, sp. nov.

*Shells:* Plate XL, figs. 4, 5, 6.

*Type-locality.*—Rio Tapajos, Santarem, Pará, Brazil (J. D. Haseman coll., December 6–12, 1919). *Type-set:* Carn. Mus. Cat. No. 61.5850. Seventeen complete shells and a number of odd valves.

*Characters of Shell.*—Shell small to medium in size (maximum length 57 mm.), moderately thick, outline briefly subelliptical, subovate, or subrotund (when young), hardly oblique. Height 75 to 86 pr. ct. of the length. Valves not gaping. Dorsal margin behind the beaks gently curved or almost straight, subconcave and very short in front of the beaks, passing gradually or at an indistinct angle into the anterior margin. Posteriorly the dorsal margin passes by a blunt, indistinct angle, or almost gradually, into the posterior margin, which descends obliquely and is gently curved. At the lower posterior end, which is little elevated above the base line, the posterior margin passes in a stronger curve into the lower margin. Lower margin very gently curved in its posterior part, sometimes almost straight and subparallel to the upper margin, so that a lowest point cannot be located. From about the middle it slopes upward, increasing the curve until it passes into the anterior margin. Thus the anterior part of the shell appears only little narrower than the posterior.

Valves very convex, convexity rather uniform over the disk, slightly stronger over the posterior ridge, which is indistinct. The posterior slope is very slightly compressed, without forming a wing-like expansion. Diameter 60 to 69 pr. ct. of the length. Beaks much swollen and inflated, incurved, strongly elevated over

the lunula, and distinctly higher than the posterior upper margin, located at 28 to 33 pr. ct. of the length. Lunula cordiform, short and broad, almost as broad as long.

Epidermis dull, with crowded, irregular, concentric lines. My specimens being all dead shells, the original structure is somewhat doubtful, but in some specimens there are distinct indications of a lamellar, cloth-like structure. No radial sculpture present, and no distinct radial rib upon the posterior slope. Color of epidermis paler or darker brown, rather uniform, often with a more or less distinct blackish ray upon the posterior slope, sometimes accompanied by a second ray.

Hinge-line gently curved or almost straight behind the beaks. Under the beaks it is sinuated, curving down more or less strongly, and then it is straight or may curve up a little, rendering the lunula slightly concave. Pseudocardinal teeth of the usual type, but somewhat variable; that of the right valve in particular may be more or less compressed. Ligamental sinus rather small, triangular, its anterior margin oblique.

Nacre white, shining in well preserved shells, iridescent, and with rather distinct radial lines. Prismatic zone narrow, without any trace of a sudden widening. Cavity of shell and beaks considerable. Anterior adductor-scar deeply impressed. Anterior retractor-scar small, close to the adductor-scar, but distinctly separated from it. Anterior protractor-scar united with adductor-scar. Posterior adductor-scar faint, subovate, with a triangular upper process formed by the posterior retractor-scar. No dorsal scars. Pallial line subconcentric to the margin.

Measurements.

| No. | Length. | Height. | Diameter. | Beaks | Figured. |
|---|---|---|---|---|---|
| 1.... | 22 mm. | 18 mm. =82 pr. ct. of L. | 14 mm. =64 pr. ct. of L. | at 6.5 mm. =30 pr. ct. of L. | Pl. XL, fig. 6. |
| 5.... | 28 " | 24 " =86 " | 19 " =68 " | 8 " =29 " | Pl. XL, fig. 5. |
| 7.... | 30 " | 25 " =83 " | 18 " =60 " | 9 " =30 " | |
| 10.... | 41 " | 33 " =80 " | 27 " =66 " | 13.5 " =33 " | Pl. XL, fig. 4. |
| 11.... | 49 " | 39 " =80 " | 34 " =69 " | 14 " =29 " | |
| 12.... | 57 " | 43 " =75 " | 35 " =61 " | 16 " =28 " | |

*Remarks.*—There cannot be any mistake about this species, which differs from all others by the greatly swollen valves and inflated beaks, which render the shape almost subglobular. The diameter of 60 to 69 pr. ct. is not found in any other species of the genus, and approached only by *M. paraguayana*, which, however, distinctly differs in shape, being subangular, strongly oblique, and having the posterior slope much compressed and subalate. In addition, the present species differs from others by the narrow prismatic zone. It is impossible to give exact figures for the location of the greatest height, as the height of the shell is essentially the same for a considerable distance behind the middle.

Only one of the described species comes near to the present one, and this is the little known *M. inermis* (Spix), as re-described by Von Ihering (1890, p. 126, Pl. 9, figs. 1–3). This is founded upon a single, and apparently very young, individual, which resembles to a degree our youngest specimens of *obesa*. Von Ihering gives the following figures for this:

| Length. | Height. | Diameter. |
| --- | --- | --- |
| 21 mm. | 15 mm. = 71 pr. ct. of L. | 10 mm. = 48 pr. ct. of L. |

This specimen is not so high, and much less swollen than *obesa*, and we could not by any means place it at the head of our table of measurements.

### 47. Monocondylæa hollandi Ortmann, sp. nov.

*Shell:* Plate XLI, fig. 1.

*Type-locality.*—Sand-bar of Rio Guaporé, near Rio São Simão, Matto Grosso, Brazil. (J. D. Haseman coll., July 20, 1909). *Type:* Carn. Mus., Cat. No. 61. 5846. One specimen, male, with soft parts.

*Characters of the Shell.*—Shell large (length 102 mm.) moderately thick, outline subcircular, almost subrhomboidal. Height 77 pr. ct. of length. Valves very little gaping, almost closed in front. Dorsal margin behind beaks practically straight, in front of them subconcave, short and much lower, passing by a very blunt angle into the anterior margin. The angle with the posterior margin is also very blunt, almost regularly rounded. Posterior margin obliquely descending and gently curved, passing in a sharper curve into the lower margin, thus forming the rounded posterior end of the shell, which is situated a good deal above the base-line. Lower margin curved, strongest curve in about the middle of the shell, forming a blunt lowermost point at 47 pr. ct. of the length (consequently a little in front of the middle). From this point the lower margin slopes up in either direction; the posterior part of the margin is almost straight; the anterior more curved, and passes in a regularly increasing curve into the anterior margin. The anterior end of the shell cannot be called narrower than the posterior.

Valves gently and regularly convex in the middle of the disk, and more so towards the beaks, distinctly compressed anteriorly and posteriorly, and the anterior compression is quite remarkable, forming a sharp, elevated, almost wing-like expansion at the anterior upper margin. Posterior ridge of shell not at all marked. Diameter 45 pr. ct. of length. Beaks somewhat inflated, not very prominent (they are eroded), located at about 37 pr. ct. of the length. Lunula short and broad.

Epidermis smooth, with irregular, concentric lines, poorly developed in the

middle of the disk and toward the beaks, slightly lamellar and more crowded on the posterior slope and near the lower margin. Upon the main part of the disk there are traces of indistinct radial lines. Posterior slope with an indistinct radial ridge. Color of epidermis yellowish brown, lighter in anterior half of the shell, darker in the posterior, the two colors divided by a rather distinct radial boundary-line through the middle of the shell. No color-rays are visible.

Hinge-line straight behind the beaks. In front it is curved down, and then it slopes up again, making the lunula slightly concave. One pseudocardinal tooth in each valve, that of the left valve standing in front of, and slightly below, that of the right. The former is vertically depressed and projects into a slight groove of the right valve. This groove has a low horizontal ridge, fitting into a groove at the base of the upper face of the tooth of the left valve; however, this may be an individual character. Tooth of the right valve subpyramidal, not depressed, projecting and fitting into a groove which is partly under the margin of the left valve (the stumpy character of this tooth may also be individual). Ligamental sinus triangular, about as deep as wide, its anterior margin oblique to the hinge-line.

Nacre white, not very iridescent,[26] with hardly any traces of radial lines. Prismatic zone comparatively narrow, slightly wider in the anterior part of the shell, but not abruptly widening anywhere.

Cavity of shell shallow, that of beaks moderate. Anterior adductor-scar sharply marked, elliptical. Anterior retractor-scar above it and close to it, but separated; in the right valve it appears double. Anterior protractor-scar connected with adductor-scar. Posterior adductor-scar less sharply marked, subovate, with a triangular process above formed by the posterior retractor-scar. No dorsal scars. Pallial line subconcentric to margin.

MEASUREMENTS.

| Sex. | Length. | Height. | Diameter. | Beaks. | Greatest Height. | Figured. |
|---|---|---|---|---|---|---|
| ♂ | 102 mm. | 79 mm. =77 pr. ct. of L. | 46 mm. =45 pr. ct. of L. | at 38 mm. =37 pr. ct. of L. | at 48 mm. =47 pr. ct. of L. | Pl. XLI, fig. 1. |

*Remarks.*—A very striking and certainly new species, although only a single individual is at hand. It is much larger than any of the known species, and has a shape characterized chiefly by the location of the greatest height in front of the middle, and the absence of a distinct narrowing of the anterior part of the shell.

[26] The nacre apparently is slightly corroded. Although the specimen was alive when found, and preserved with the soft parts, the uppermost layer of the nacre has been injured and is exfoliating. According to my experience, this happens when specimens are allowed to die before they are put in alcohol.

It is also remarkable for the yellowish brown color of the epidermis, but this may be variable. In the relative dimensions it comes near *M. lentiformis* (height and diameter), and it is also a decidedly flat shell, although the beaks are slightly more inflated than in *lentiformis*. The compression of the anterior extremity also should be noted.

I name this species in honor of Dr. W. J. Holland, Director of the Carnegie Museum, under whose auspices the expedition to Central South America by Mr. John D. Haseman was made.

*Anatomy.*—The specimen at hand is a male.

Soft parts like those of the foregoing species, but the following points should be mentioned: the inner edge of the anal opening is practically smooth, that of the branchial opening with very minute papillæ, which appear as mere crenulations; the gills have solid septa, which are unequal in thickness, heavier and lighter ones alternating in a more or less regular way, chiefly so in the middle of the gills.

### Genus Anodontites Bruguière (1792).

*Anodontites* Bruguière, Journ. Hist. Nat., Paris I, 1792, p. 131; Pilsbry, 1911, p. 609; Ortmann, 1911*c*, p. 91; Simpson, 1914, p. 1403.

*Patularia* Swainson, Malacology, 1840, p. 287, 381.

*Glabaris* Gray (1847) Simpson, 1900, p. 916.

In this genus the hinge is without any teeth. From *Mycetopoda* and *Leila* it differs by the absence of the characters peculiar to these, *i.e.*, in the shape of the shell, and certain features of the soft parts (See key p. 568). Furthermore we find in *Anodontites* an extreme variability in the shape of the shell, from rounded and subovate, to subtrapezoidal and elongated. The number of species is very great, and it is hard to arrange them. Simpson (1914) distinguishes three sections.

1. Section *Anodontites* (*sensu stricto*). Shell rounded to elliptical; posterior ridge low or wanting.

2. Section *Styganodon* Von Martens (1900). Shell subrhomboidal, with a thick, dark, rather rough, sombre-colored epidermis, which is sometimes faintly rayed; nacre lurid, shaded green.

3. Section *Virgula* Simpson (1900). Shell subsolid to solid, moderately inflated, greatly elongated, straight or falcate, rounded in front, sharply pointed at the posterior base, where the high, sharply defined posterior ridge ends, and above which it is somewhat obliquely truncated; beaks not high; epidermis green to olive; nacre brilliant, blueish or purplish, iridescent, rayed with very fine, indistinct ridges; posterior end with a slight sinus.

It is seen at a glance that these three sections are not uniformly well defined. *Virgula*, indeed, is sharply separated from the rest. *Styganodon* is well characterized by the epidermis; but unfortunately the type of the genus (*Anondontites crispata*) undoubtedly belongs to *Styganodon*, having an epidermis (thick, dark, rough, sombre-colored) which represents an extreme development of the *Styganodon*-structure; in other characters also, *A. crispata* is closely allied to *A. tenebricosa*,[27] the type of Styganodon.

It is clear that, on the one hand, *Anodontites* (*sensu strictiore*) must be used for *crispata*, and, on the other hand, that *Styganodon* is a synonym of this, the type of the latter being closely related to *crispata*. This necessitates a re-arrangement of the sections, and a revision of their nomenclature. Although I have good material representing the genus, it is impossible for me to attempt a final classification, and the one given below is primarily adapted to the material at hand. An attempt is made to preserve Simpson's groups as far as possible.

*Geographical distribution:* The genus is widely distributed over South America east of the Cordilleras from Patagonia to the Caribbean Sea, being found also in the northern parts, where *Diplodon* and the *Hyriinæ* in general are rare, or absent. West of the Cordilleras it is generally missing, but it has been reported from that side in Ecuador (the fact, however, requires confirmation). In addition the genus has extended its range northward into Central America and Mexico, where it is found in both the Pacific and Atlantic drainages.

Key to the Groups of Anodontites.

$a_1$. Shell not greatly elongated, nor pointed behind, without sharp posterior ridge. Posterior retractor-scar connected with adductor-scar. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . Subgenus *Anodontites s. s.*

- $b_1$. Epidermis dull, densely wrinkled.
  - $c_1$. Shell more or less elongated, but not distinctly oblique and subcircular.
    - $d_1$. Shell subtrapezoidal, somewhat elongated. Lower margin straight or concave. Group of *A. crispata*.
    - $d_2$. Shell subovate or subelliptical, rather short. Lower margin convex. Group of *A. obtusa*.
  - $c_2$. Shell distinctly oblique, short and high, nearly subcircular. . . . . . . . . . Group of *A. trapezea*.
- $b_2$. Epidermis more or less shining, wrinkles only partially developed or absent. Shell straight or oblique, often distinctly so.
  - $c_1$. Shell not very oblique; straight, rather elongated, more or less pointed behind. Prismatic border narrow, of equal width. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . Group of *A. trigona*.
  - $c_2$. Shell strongly oblique, not much elongated, not, or very little, pointed behind.
    - $d_1$. Shell subovate or subrotund. Prismatic border wide, width unequal. Group of *A. patagonica*.

[27] Another species, *A. napoënsis*, allied to *crispata*, has been placed in *Styganodon* by Haas (1916, pp. 32, 55).

$d_2$. Shell subovate or subtrapezoidal. Prismatic border narrow and of equal width. Group of *A. trapesialis*.

$a_2$. Shell greatly elongated, sharply pointed behind, with a sharp posterior ridge. Posterior retractor-scar completely separated from adductor-scar. Epidermis not shining, covered with fine wrinkles. Subgenus *Lamproscapha*.

## Subgenus ANODONTITES *s. s.*

*Anodontites s. s.* + *Styganodon* VON MARTENS, SIMPSON, 1914, pp. 1403, 1448.

Shell of various shapes, but not greatly elongated or pointed behind, without sharp posterior ridge. Posterior retractor-scar connected with adductor-scar.

### 1. *Group of Anodontites crispata.*

Group of *A. crispatus* SIMPSON, 1914, p. 1414 (*pars*) + Section *Styganodon*, group of *A. tenebricosus*, SIMPSON, ibid., p. 1448.

Shell not, or very little, oblique, subtrapezoidal, rather elongated, with the lower margin straight or more or less concave (sinuated). Epidermis dull, dark, not rayed, not smooth, but strongly and densely sculptured all over by concentric or radial, or irregular wrinkles. Prismatic border narrow or wider, of nearly equal width.

The most essential feature of this group is in the texture of the epidermis, and its somber color. The nacre also is peculiar, being dull and lurid.

These forms greatly resemble certain African species of *Spatha*, subgenus *Aspatharia*, and I am strongly inclined to think that of all South American types of *Mutelinæ* these show the closest affinities to that African group. In *A. crispata* occasionally a single dorsal muscle-scar is present, which also agrees with the condition regularly seen in *Spatha*.

Three species belonging here are known to me in nature. They may be distinguished as follows:

$a_1$. Wrinkles of epidermis arranged concentrically and radially, the radial tendency prevailing. Prismatic border moderate. . . . . . . . . . *A. crispata*.

$a_2$. Wrinkles of epidermis with concentric tendency prevailing, radial arrangement obscure.
- $b_1$. Shell comparatively shorter and higher, beaks more median in position. . . . . . . . . . *A. tenebricosa*.
- $b_2$. Shell comparatively longer and lower, beaks more anterior in position. . . . . . . . . . *A. clessini*.

### 48. ANONDONTITES CRISPATA[28] Bruguière (1792).

*Shells:* Plate XL, figs. 7, 8; Plate XLI, figs. 2, 3.

*Anodontites crispata* BRUGUIÈRE, Journ. Hist. Nat. Paris, I, 1792, p. 131; SIMPSON, 1914, p. 1415.

*Anodon reticulatus* SOWERBY, XVII, 1867, Pl. 10, fig. 27.

[28] Bruguière uses *Anodontites* as *feminini generis*, and this should not be changed.

*Glabaris crispatus* SIMPSON, 1900, p. 919.

*Type-locality.*—South America.

*Other Localities.*—Cayenne (Lea, Syn., 1870, p. 106); Amazon River (Sowerby, *reticulatus*).

*New Locality.*—Rio de la Paila, Paila, U. S. of Colombia (C. H. Eigenmann coll., 1912). About twenty specimens, ten of them with soft parts, males and females. (The Rio de la Paila is a tributary of the upper Rio Cauca of the Rio Magdalena-drainage).

*Distribution.*—Simpson says that this species is widely distributed in tropical South America, though but few exact localities are known.

*Characters of the Shell.*—Of medium size (maximum length 67 mm.), moderately thick, rather thin when young. Outline elongated subtrapezoidal, or subelliptical. Height 52 to 61 pr. ct. of the length. Valves practically closed, or very little gaping in front. Dorsal margin straight, or prevalently very gently curved behind the beaks, descending in front of the beaks, and passing gradually into the anterior margin. Posteriorly it forms a blunt angle with the posterior margin, or passes into it in a curve. Posterior margin curved, obliquely descending in its upper part, becoming gradually steeper, and sometimes nearly vertical at the posterior end, which is blunt and rounded, but bends rather suddenly into the lower margin. The posterior end is thus very little elevated above the base-line, often practically at its level. Lower margin straight for a considerable distance, often even slightly concave in the middle, gently sloping upward toward the front and curving up into the anterior margin. This ascending part, and the descending anterior upper margin, make the anterior end of the shell narrower, but the whole shell does not appear very oblique. The highest part of the shell is in the posterior section.

Valves moderately convex, rather flattened upon the sides, and sometimes even with a shallow depression corresponding to the emargination of the lower margin. Posterior ridge broad and rounded, indistinct, but the greatest diameter of the shell (31 to 38 pr. ct. of length) is situated upon it, so that the shell is more swollen posteriorly than anteriorly. Posterior slope slightly compressed, sometimes with a very faint radial groove. Beaks not swollen and not elevated above the hinge-line, located at 27 to 33 pr. ct. of the length. Lunula indistinct or narrow, not very long.

Epidermis finely wrinkled all over, the wrinkles partly concentric, but prevailingly arranged in a radial pattern. Concentric and lamellar wrinkles are found chiefly near the margins. Upon the disk, the pattern varies in the anterior and

posterior section of the shell. Anteriorly there are short, concentric wrinkles, arranged in scalariform, radial bands. Posteriorly the wrinkles are rather irregularly radial, assuming generally an oblique direction, forming radial bands of loops or V-shaped festoons, often anastomosing, and more or less reticular ("like dried paint"). In the middle of the shell the two types of sculpture pass into each other: the short, subconcentric, scalariform wrinkles become rather suddenly V-shaped, and assume the oblique or radial direction. On the posterior slope and near the lower margin, the wrinkled sculpture is more or less obscured by sublamellar concentric striæ. Color of epidermis, in very young specimens, yellowish; later it becomes brownish olive or dark greenish to blackish, generally more brownish toward the beaks, and more blackish toward the margins. Sometimes (in strong transmitted light) there are dark color rays upon the posterior slope.

Hinge-line nearly straight or gently convex posteriorly, descending anteriorly, a little irregular just in front of the beaks. Ligamental sinus moderate, triangular, wider than deep, its anterior margin slightly oblique to the hinge-line. Nacre bluish white, grayish white, lurid, often showing brownish or greenish discoloration. Prismatic border rather narrow, subequal in width, of grayish color.

Cavity of shell and beaks shallow. Anterior adductor-scar well marked, impressed, irregularly elliptical. Anterior retractor-scar only partially separated from adductor-scar, connected with it narrowly or more broadly, and very variable in this respect. Anterior protractor-scar separated from adductor-scar. Posterior adductor-scar less impressed, rounded or subovate, posterior retractor-scar forming an upper process of it. Dorsal scars generally absent, but in a few cases there is an indistinct single one. Pallial line distinct, simple, subparallel to the margin.

MEASUREMENTS.

| No. | Sex. | Length. | Height. | Diameter. | Beaks. | Figured. |
|---|---|---|---|---|---|---|
| 1.... | ♂ | 24.5 mm. | 15 mm. =61 pr. ct. of L. | 8.5 mm. =35 pr. ct. of L. | at 7 mm. =29 pr. ct. of L. | |
| | ? | 37 " | 19.5 " =53 " | 11.5 " =31 " | 10 " =27 " | Pl. XLI, fig. 3. |
| 2.... | ♀ | 45 " | 27.5 " =61 " | 17 " =38 " | 15 " =33 " | |
| 5.... | ♀ | 56 " | 29 " =52 " | 19.5 " =35 " | 15 " =27 " | |
| 10.... | ♀ | 63.5 " | 35 " =55 " | 22 " =35 " | 18 " =28 " | Pl. XL, fig. 8. |
| | ? | 67 " | 35 " =52 " | 22 " =33 " | 19 " =28 " | Pl. XLI, fig. 2. |
| Simpson..... | | 53 " | 27.5 " =52 " | 17 " =32 " | | |

*Remarks.*—I have no doubt that my specimens represent *A. crispata*. They agree fairly well with Sowerby's figure of *Anodon reticulatus*, and very well with Simpson's description. But there are several closely allied, if not identical, species, chiefly *A. napoënsis* Lea (Obs. XII, 1869, Pl. 53, fig. 137, and Germain, 1910, p. C 64, Pl. 2, figs. 3, 4) from Rio Napo (tributary to the upper Amazon in Ecuador) and Rio Unuyacu (tributary to Napo). This species differs chiefly in the posterior

end of the shell, which is more elevated above the base-line, and in the more curved ventral margin. The sculpture of this species undoubtedly is similar, but the details have not been described.

Simpson says that this species is very variable in sculpture. However, I find that my specimens (twenty at hand) are rather uniform in this respect. Only in the youngest specimen is the subradial sculpture of the posterior part not so well developed; but in the second (37 mm. long) it is distinctly seen.

There is a good deal of variation in the shape of the posterior end, and the posterior margin may be more oblique or may be more vertical in its lower part. Very often the nearly vertical truncation of the posterior end produces the appearance of a biangulation, chiefly when the faint groove of the posterior slope is visible.

*Anatomy.*—Soft parts of six males and four barren females at hand for study. Anal opening separated from the branchial by a mantle connection, open and nowhere closed, its inner edge smooth or nearly so. Branchial opening with fine papillæ. Palpi longer than high, lower margins convex, posteriorly truncated, the truncation forming the short posterior margins, which are connected at base only.

Gills of medium width, the inner the wider anteriorly, its anterior end immediately behind the palpi, and attached to the whole interval between the palpi and the anterior end of the outer gill. The latter at the highest point of the mantle-attachment-line. Inner lamina of inner gill entirely connected with abdominal sac.

Gills with well developed septa. In the non-marsupial gills the septa are irregularly alternating, stronger and weaker. In the female the inner gill is *marsupial* for nearly its whole length, with stronger and more uniform, but not more crowded, septa. The septa possess the usual swelling, forming vertical ridges projecting into the lumen of the water-tubes, dividing the latter into an inner compartment (ovisac), and an outer (secondary water-tube).

### 49. Anodontites tenebricosa (Lea) (1834).

*Anodonta tenebricosa* Lea, Obs., I, 1834, Pl. 12, fig. 36; D'Orbigny, 1843, p. 616.
*Anodon tenebrosa* Sowerby, XVII, 1867, Pl. 13, fig. 43.
*Anodon tenebricosa* Sowerby, XVII, 1870, Pl. 31, fig. 123.
*Anodonta tenebricosta* Corsi, 1901, p. 457, fig. 58.
*Glabaris tenebricosa* Von Ihering, 1893, p. 61; Nehring, 1893, p. 163; Simpson, 1900, p. 930.

*Anodontites tenebricosus* SIMPSON, 1914, p. 1448.
*Anodontites* (*Styganodon*) *tenebricosus* HAAS, 1916, pp. 35, 57.

*Type-locality.*—Rio Paraná.

*Other Localities.*—Rio San José and Arroyo del Rosario, Uruguay (D'Orbigny) (tributaries to La Plata in the Banda Oriental); Rio de la Plata, Buenos Aires, Argentina (D'Orbigny); Buenos Aires (Haas); Rio Uruguay, Salto Oriental, Uruguay (Haas); Rio Piracicaba, Piracicaba, São Paulo, Brazil (Von Ihering) (Nehring).

*New Localities.*—Pond along banks of Rio Negro, Santa Isabel, Uruguay (J. D. Haseman coll., February 11, 1909). One complete specimen and one left valve. Rio de la Plata, San Isidro, 20 km. North of Buenos Aires, Argentina (A. Windhausen coll., January, 1917). One female with soft parts.

*Distribution.*—From the region of Buenos Aires in the La Plata system and its tributaries in Uruguay (smaller streams of the Banda Oriental and Rio Uruguay-system) up the Paraná River to its headwaters in São Paulo, Brazil.

Simpson gives a much larger range, adding even Ecuador and Peru, but I do not know on what authority.

This species is well known and has been well described. Its chief characters are its shape, which, although elongated-subtrapezoidal, is rather short and high in comparison with the related species. The prismatic border of the shell, chiefly in old shells, is remarkably wide, but subequal in width, not suddenly changing anywhere.

The character of the epidermis has been given as concentrically lamellose. This is correct, and the fine, crowded, concentric lamellæ are very obvious. However, closer investigation shows that between these lamellæ are additional, more irregular wrinkles, which produce upon the posterior part of the shell a reticulated (anastomosing) sculpture, and more anteriorly these wrinkles may be even radial. But they exist only between the concentric lamellæ, and thus they are very short and largely obscured by the concentric sculpture. This difference of sculpture from that of *A. crispata* is very striking. Otherwise these two species have many features in common.

MEASUREMENTS.

| | Sex. | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|---|
| S. Isabel............ | ? | 57 mm. | 33 mm. =58 pr. ct. of L. | 17 mm. =29 pr. ct. of L. | at 18 mm. =32 pr. ct. of L. |
| S. Isidro............ | ♀ | 92 " | 54 " =59 " | 32 " =35 " | 27 " =29 " |

According to Von Ihering's measurements, the height is 53 pr. ct. and the diameter 34 pr. ct. of length. According to Nehring's measurements the height is 48 to 55 pr. ct., the diameter 30 to 33 pr. ct. Thus specimens from the upper

Paraná-drainage seem to be not so high, more elongated than those from the lower part of the system. In Lea's original specimen (according to figure and measurements given by Simpson), the height is 55 pr. ct., the diameter 45 pr. ct. of length. In another specimen measured by Simpson, the height is 60 pr. ct., the diameter 38 pr. ct. D'Orbigny's measurements give for height 58 pr. ct. and for diameter 37 pr. ct. These latter figures agree very well with mine, and it should be noted that the larger specimens generally give a proportionally greater diameter.

*Anatomy.*—The soft parts of one barren female are at hand for examination.

Practically identical with the preceding species. The gills, in the present specimen, appear comparatively narrow. The structure of the *marsupium* (inner gill) is typical. The swellings of the septa are very distinct, and are situated closer to the outer lamina (primary limb).

### 50. Anodontites clessini (Fischer) (1890).

*Shells:* Plate XLI, fig. 4; Plate XLII, figs. 1, 2. *Anatomy of gills:* Plate XLVII, fig. 4.

*Mycetopus plicatus* Clessin, Malakozoöl. Blætt., LI, 1882, p. 190, Pl. 4, fig. 7 (*nomen præoccupatum*).

*Mycetopus clessini* Fischer, Journ. de Conchyliol., XXXVIII, 1890, p. 8, footnote.

*Glabaris nehringi* Von Ihering, 1893, p. 60; Nehring, 1893, p. 163; Von Ihering, 1910, p. 139.

*Glabaris clessini* Simpson, 1900, p. 930.

*Anodontites clessini* Simpson, 1914, p. 1450.

*Type-locality:* ?

*Other Localities.*—Rio Sta. Maria, Rio Grande do Sul, Brazil (Von Ihering) (tributary to Ibicuhy and Uruguay); Rio Piracicaba, Piracicaba, São Paulo, Brazil (Von Ihering); Rio Piracicaba Mirim, Piracicaba, São Paulo, Brazil (Nehring); Rio Paraguassú, Bahia, Brazil (Von Ihering, 1910).

*New Locality.*—Rio Vaccahy Mirim, Santa Maria (da Bocca do Monte), Rio Grande do Sul, Brazil (J. D. Haseman coll., January 29, 1909). Twelve specimens, all with soft parts, males and females.

*Distribution.*—Positively known from the Uruguay drainage and the headwaters of the Paraná. In addition, it has crossed over into certain coastal streams in Brazil. Our locality in Rio Vaccahy Mirim belongs to the Jacuhy-Guahyba-system, but is close to Von Ihering's record from the Uruguay drainage, but on the other side of the divide. This species has been found also in the Rio Paraguassú in Bahia, well to the North, and separated from the rest of the range in the upper Paraná (Piracicaba). But probably some kind of connection will be found.

This species may be regarded as an elongated and narrow *tenebricosa*. In consequence of the general elongation, the posterior margin forms a more obtuse angle with the upper margin, and the posterior end is not subtruncated, but more evenly and narrowly rounded. Young specimens are almost regularly long-elliptical. The prismatic zone is comparatively narrow. The ligamental sinus is triangular, wider than deep, and its anterior margin forms an obtuse angle with the hinge-line (being directed obliquely backwards), or is almost vertical. (In *A. tenebricosa* this sinus is about as deep as wide, its anterior margin is nearly vertical and curved gently forwards, so that the lower point, which is quite sharp, is directed obliquely forward).

In all other characters the two species resemble each other, and this is pre-eminently true of the sculpture of the epidermis.

MEASUREMENTS.

| No. | Sex. | Length. | Height. | Diameter. | Beaks. | Figured. |
|---|---|---|---|---|---|---|
| 1.. | ♂ | 31 mm. | 16 mm. =52 pr. ct. of L. | 8.5 mm. =24 pr. ct. of L. | at 10 mm. =32 pr. ct. of L. | |
| 4.. | ♂ | 45 " | 22 " =49 " | 13 " =29 " | 12 " =26 " | |
| 8.. | ♀ | 61 " | 27 " =44 " | 19 " =31 " | 17 " =28 " | |
| 11.. | ♀ | 68 " | 34 " =50 " | 20 " =29 " | 19 " =28 " | Pl. XLII, fig. 2. |
| 10.. | ♀ | 69 " | 31 " =45 " | 23 " =33 " | 18 " =26 " | Pl. XLI, fig. 4; |
| 12.. | ♂ | 70 " | 32 " =46 " | 21 " =30 " | 18 " =26 " | Pl. XLII, fig. 1. |

According to Von Ihering, the height is from 43 to 51 pr. ct., the diameter from 22 to 33 pr. ct. of length, the beaks are at 24 to 31 pr. ct. According to Nehring, the height is 41 to 43 pr. ct., the diameter 20 to 25 pr. ct. In *A. tenebricosa*, the figures for the height are 55 to 60 pr. ct. (rarely below this); for the diameter 29 to 45 pr. ct. and for the beaks 29 to 34 pr. ct.

*Remarks.*—The greater length of the shell is brought out by these figures, and also the lesser obesity and more anterior position of the beaks, which results from it. It is also seen in my specimens that the elongation is not so great in younger specimens, and in the latter the measurements approach those of *tenebricosa*, or even fall within the range of variation of it. It is possible that the two species actually intergrade, a condition which has been hinted at by Nehring (p. 164) to exist in the Rio Piracicaba.

*Anatomy.*—The soft parts of seven males and five barren females have been investigated.

Color of soft parts whitish; inner edge of anal and branchial openings black, the black color running forwards from the branchial for a certain distance.

Anal opening entirely open, its inner edge practically smooth, separated from the branchial opening by a connection of the mantle-margins. Inner edge

of branchial opening with distinct, but small papillæ. Palpi rather small, semicircular, shortly truncated posteriorly, thus forming posterior margins, which are not connected.

Gills (Pl. XLVII, figs. 4*a*, *b*) long and narrow, the inner considerably wider than the outer, chiefly anteriorly. Anterior end of inner gill immediately behind the palpi. Inner lamina of inner gill entirely connected with abdominal sac. Septa well developed, those of the non-marsupial gills alternately somewhat stronger and weaker, best seen in the outer gill of the female (Pl. XLVII, fig. 4*b*). Inner gill of female *marsupial* for nearly its whole length, with more uniform, thicker, but not more crowded septa, which have the usual swellings near their contact with the outer lamina.

### 2. *Group of Anodontites obtusa.*

Simpson, 1914, p. 1453.

Shell not very oblique, subovate or subelliptical, rather short, lower margin convex. Epidermis dull, greenish, often with rays, concentrically lamellarly wrinkled. Prismatic border narrow.

The few forms belonging here are closely allied to the first group, and have indeed been placed in the section of *Styganodon* by Simpson. They are shorter, higher than those of the *crispata*-group, with more inflated beaks, and have an unusual development of color-rays. The sculpture of the epidermis is much like that of *tenebricosa* and *clessini*, and consists of close, sublamellar, concentric wrinkles, here and there subreticulated.

### 51. Anodontites obtusa (Spix) (1827).

*Anodon obtusum* Spix, 1827, Pl. 22, fig. 3; Wagner, Ibid, p. 30.
*Anodon lituratum* Spix, Ibid, Pl. 22, fig. 4.
*Anodonta obtusa* and *litturata* Hupé, 1857, pp. 86, 87, Pl. 17, fig. 4.
*Anodon obtusus* Sowerby, XVII, 1867, Pl. 12, fig. 39.
*Anodon liturata* Sowerby, Ibid, 1868, Pl. 20, fig. 78.
*Anodonta obtusa* Von Ihering, 1890, p. 159.
*Glabaris obtusus* and *lituratus* Simpson, 1900, p. 931.
*Anodonta* (*Glabaris*) *obtusa* Germain, 1910, p. 63, Pl. 3, figs. 14, 15.
*Anodontites obtusus* and *lituratus* Simpson, 1914, pp. 1453, 1454.

*Type-locality.*—Rio Paraguassú, Bahia, Brazil.

*Other Records.*—Rio Paraguassú (Von Ihering, 1910, p. 139); Rio São Francisco, Villa Nova, Sergipe, Brazil (Von Ihering); Rio São Francisco, Joazeiro, Bahia, Brazil (Von Ihering); Rio das Velhas, Minas Geraes, Brazil (Von Ihering) (upper

S. Francisco-drainage); Bodegas, and Rio Daule, Ecuador (Germain) (Pacific-drainage, near Guayaquil).

*New Locality.*—Lagoa Sacho Grande, Cidade da Barra, Bahia, Brazil (J. D. Haseman coll., December 24, 1907). One young specimen. (S. Francisco-drainage).

Another, larger specimen is in the Carnegie Museum, from the Holland Collection, labeled "Brazil."

*Distribution.*—Known from the drainages of Rio Paraguassú and São Francisco. Von Ihering gives a possible variety, similar to the var. *hohenackeri*, from Rio Mucury, Bahia (southern part) (1890, p. 161), and another variety (*juparana*, 1910, p. 131) from Lagoa Juparana of Rio Doce, Espirito Santo).[29] The form is not known from the basin of the Amazon. So much more astonishing is Germain's record of this species from the Pacific slope in Ecuador. I cannot discover any differences in these specimens, but attention should be called in this connection to *A. aff. pastasanus* of Haas (1916, pp. 34, 56, Pl. 2, fig. 1) which comes from the identical localities (Rio Daule and Bodegas in Ecuador). The latter, however, is more elongated than Germain's figure of *obtusa*, and cannot be the same.

Simpson also cites Paraguay, but I do not know on what authority.

After what Wagner and Von Ihering have said, it is perfectly clear that *liturata* is the young stage of *obtusa*, and my larger specimen shows, near the beaks, the juvenile character of broken and oblique rays. Hupé says that *liturata* is less swollen than *obtusa*, while Simpson (1914, p. 1454) states the opposite, that it is more inflated (possibly slip of the pen). Of my two specimens it is the smaller one, with *liturata*-color-markings, which is the more swollen.

MEASUREMENTS.

| | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|
| Barra...... | 36 mm. | 24 mm. = 67 pr. ct. of L. | 17 mm. = 47 pr. ct. of L. | at 12 mm. = 33 pr. ct. of L. |
| Brazil...... | 47 " | 32 " = 68 " | 19 " = 40 " | 17 " = 36 " |
| Spix' type.. | 53 " | 35 " = 66 " | 25 " = 47 " | |

## 3. GROUP OF ANODONTITES TRAPEZEA.

Shell subcircular, but distinctly oblique, short and high. Epidermis dull, densely, concentrically, lamellarly wrinkled. Prismatic border moderate, or narrow, of nearly equal width.

The subcircular shape and the dull, cloth-like epidermis are found in no other group combined.

[29] In 1910 (p. 131) he says that specimens from Rio Mucury are *juparana*.

52. Anodontites trapezea (Spix) (1827).

*Anodon rotundum* and *trapezeum* Spix and Wagner, 1827, p. 28, Pl. 20, figs. 1–4.
*Anodonta rotunda* and *trapezea* Von Ihering, 1890, pp. 142, 145, Pl. 9, figs. 5, 6.
*Anodonta cailliaudi* Lea, Obs., X, 1863, Pl. 45, fig. 297.
*Anodon cailliaudi* Sowerby, XVII, 1867, Pl. 12, fig. 38.
*Glabaris rotunda* Von Ihering, 1893, p. 59; Simpson, 1900, p. 918.
*Glabaris trapezea* Von Ihering, 1893, p. 57; Nehring, 1893, p. 163; Von Ihering, 1910, p. 138.
*Anodontites rotundus* Simpson, 1914, p. 1410.

D'Orbigny first recognized the identity of *trapezea* and *rotunda*, and selected the first name. Although the specimens from Corrientes, to which he applied this name, may not have been the typical *trapezea*, but a variety or even a species (*spixi* D'Orbigny, 1835), his selection of *trapezea* in preference to *rotunda* should be accepted.

*Type-locality.*—Rio Solimões (middle Amazon) Brazil.

*Other Localities.*—Rio São Francisco, Villa Nova, Sergipe, Brazil (Von Ihering, *trapezea*); São Paulo, Brazil (Wagner, *rotunda*); Rio Piracicaba, Piracicaba, São Paulo, Brazil (Von Ihering, *trapezea*).

This species, partly as *rotunda*, partly as *trapezea*, has been reported (D'Orbigny, Lea, Von Ihering) from the lower Rio Paraná (near Corrientes). However, the *A. trapezea* of D'Orbigny is believed to be a different form or variety (*A. spixi* D'Orbigny). It is surely allied to *trapezea*.

*New Localities.*—Lagoa de Sacho Grande, Cidade da Barra, Bahia, Brazil (J. D. Haseman coll., December 24, 1907). Six complete shells and four odd (left) valves. Lagoa de Sacho Pequeno, Cidade da Barra, Bahia, Brazil (J. D. Haseman coll., December 24, 1907). Three specimens, one a male with soft parts. Rio Grande, Barreiras, Bahia, Brazil (J. D. Haseman coll., January 4, 1908). Three males with soft parts. Rio São Francisco, Joazeiro, Bahia, Brazil (J. D. Haseman coll., February 28, 1908). One odd (left) valve.

All these localities are in the drainage of the Rio São Francisco.

*Distribution.*—The presence of this species in the system of Rio São Francisco is established. Since Von Ihering has also cited it as *trapezea* from the upper Paraná (Piracicaba) in São Paulo, it must belong to both systems. Farther down the Paraná (Corrientes, Argentina) similar shells are present, but apparently slightly different from the type. The original locality is in the Amazon-drainage, but it has not subsequently been found there.

*Characters of the Shell.*—Shell of moderate size (maximum length 75 mm.),

rather thin when young, slightly more solid when older, but never of considerable thickness. Outline subcircular, but a little irregular and variable, and distinctly oblique. Height 80 to 93 pr. ct. of the length. Valves not gaping. Dorsal margin nearly straight. Posterior and anterior margins uniting with the dorsal in blunt angles. Posterior margin obliquely descending, first straight, then curved, and passing in a rather regular curve in the posterior part of the lower margin, without any trace of a posterior point. Lower margin ascending forward more strongly, and curving up into the anterior margin, so that the anterior part of the shell appears somewhat narrower than the posterior part, thus producing the obliquity.

Valves inflated, diameter 49 to 56 pr. ct. of the length. Beaks somewhat swollen and inflated, elevated above the hinge-line and incurved, their tips immediately above the hinge-line in the young, a little higher in older shells. Location of beaks at 33 to 44 pr. ct. of the length. Outer surface of shell rather regularly convex, but anterior and posterior slopes somewhat compressed. Posterior ridge quite indistinct.

This species is remarkable for the presence of *beak-sculpture*, which is generally absent in this subfamily. However, I think that this sculpture is not genetically connected with that of other *Naiades*, but probably is independently developed. Quite a number of my younger specimens show it. The very tip of the beak appears as a small tubercle, and is succeeded by three to five concentric bars, which follow the growth-lines, and are low and rounded, but perfectly distinct in the middle, disappearing anteriorly and posteriorly. These bars are restricted to and crowded together at the extremity of the beaks, and disappear at a short distance (3 to 4 mm.) from them.

Epidermis with fine and crowded, concentric, somewhat anastomosing lines, which become lamellarly elevated toward the margins, and in well preserved shells, chiefly young ones, they have this character all over the shell. In addition there may be fine and faint radial striæ, but there are no scalariform stripes. In old and partly worn shells the surface becomes rather smooth, but remains always dull, and is not shining. Color of epidermis from dark green to yellowish brown. The normal color in young specimens seems to be lighter or darker green, sometimes with indistinct dark green rays (seen only in transmitted light). In older specimens the color becomes greenish brown to light brown, due to partial abrasion of the epidermis. There are always two more or less distinct dark green or blackish rays upon the posterior slope, often accompanied by two lighter, yellowish rays. Larger specimens may have a few dark brown growth-rests.

Hinge-line practically straight in young shells; in older shells it curves gently down under the beaks, and up again at the anterior end, and the posterior end curves gently down, thus forming a slight S-curve. Ligamental sinus triangular, not deeper than wide, varying with age (shallower in young shells), its anterior margin running obliquely backward in the young, and vertically in older individuals; its lower point may be sometimes directed forwards.

Cavity of shell and of the beaks rather deep, corresponding to the obesity of the shell. Nacre white; in young shells bluish white, in older shells somewhat inclining to cream-color, always extremely glossy, silvery, and iridescent toward the margins, with fine, straight, and irregular radiating lines. Along the margin there is a rather narrow nacreless (prismatic) zone, relatively wider in young specimens. This zone is subconcentric with the shell-margin, widest in the middle, gradually narrowing towards the ends, but nowhere suddenly or markedly changing its width.

Anterior adductor-scar and anterior retractor-scar united, not deep, irregularly ovate or elliptical; anterior protractor-scar connected with adductor-scar, or, in old specimens, more or less (sometimes distinctly) separated. Posterior adductor-scar faint, subovate, the posterior retractor-scar forming an upper projection thereof. No dorsal scars. Pallial line subconcentric to margin.

MEASUREMENTS.

| Location. | No. | Sex. | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|---|---|
| Sacho Grande.... | *a* | ? | 30 mm. | 24 mm. =80 pr. ct. of L. | 15 mm. =50 pr. ct. of L. | at 13 mm. =43 pr. ct. of L. |
| Sacho Pequeno... | | ♂ | 41 " | 34 " =83 " | 21 " =51 " | 18 " =44 " |
| Barreiras........ | 1 | ♂ | 47 " | 42 " =89 " | 24 " =51 " | 18 " =38 " |
| Do. ........ | 3 | ♂ | 54 " | 47 " =87 " | 27 " =50 " | 20 " =37 " |
| Sacho Grande.... | *b* | ? | 58 " | 48 " =83 " | 30 " =52 " | 24 " =41 " |
| Do. .... | *c* | ? | 68 " | 63 " =93 " | 38 " =56 " | 30 " =44 " |
| Sacho Pequeno... | | ? | 72.5 " | 61.5 " =85 " | 38 " =52 " | 24 " =33 " |
| *trapezea*, type.............. | | | 63 " | 52 " =84 " | 31 " =49 " | (Von Ihering) |
| *rotunda*, type.............. | | | 42 " | 36 " =86 " | 22 " =52 " | Do. |
| *trapezea* (Piracicaba)........ | | | 60 " | 49 " =82 " | 33 " =55 " | Do. |
| *rotunda* (Simpson).......... | | | 75 " | 64 " =85 " | 38 " =51 " | |

The variety (or species )*spixi* D'Orbigny from the lower Paraná at Corrientes grows larger, reaching the length of 81 mm. according to Von Ihering, and of 90 mm. according to D'Orbigny.

*Remarks.*—This shell is easily recognized by the general shape and proportions, by the rather narrow prismatic border, and by the dull, greenish color of the epidermis. That *trapezea* and *rotunda* are only the old and the young stages of the same species, is conclusively shown by our material, chiefly by the sets from Cidade da Barra. The old specimens have the beaks a little elevated above the hinge-line, and the hinge-line is gently curved; while the young specimens have the point

of the beaks immediately above the hinge-line, and have the latter straight. Specimens of intermediate size intergrade in these characters.

*Anatomy.*—The soft parts at hand are not in good condition. However, the structure of the gills can be made out, and according to the alternation of stronger and weaker septa, all four specimens at hand are males.

In other respects the usual structure of the genus is seen. Anal opening entirely open, separated from the branchial by a mantle-connection. Branchial opening with distinct, but small papillæ. Palpi small, subcircular, with a short truncation at the posterior end; the posterior margins not connected. Inner lamina of inner gill entirely connected with abdominal sac.

### 4. Group of *Anodontites trigona.*

Simpson, 1914, p. 1441.

Shell not very oblique, rather elongated, subelliptical, or subovate, narrowly rounded, or somewhat pointed behind. Epidermis more or less shining, and not uniformly and densely covered with wrinkles, although such are present here and there. Prismatic border narrow, of nearly equal width.

This group is poorly defined. Its chief character is the rather elongated shell, somewhat pointed behind, or narrowly rounded, and not distinctly oblique. The comparatively smooth epidermis is another noticeable feature, but still there are species, which have sublamellar, concentric striæ, at least in parts of the shell. The color of the epidermis is not so sombre and dull as in the preceding groups. The narrow prismatic border seems to be constant.

### 53. Anodontites trigona (Spix) (1827).

*Anodon trigonum* Spix & Wagner, 1827, p. 29. Pl. 22, fig. 2.
*Glabaris trigonus* Simpson, 1900, p. 928.
*Anodontites trigonus* Simpson, 1914, p. 1441.
*Anodon moretonianus* Sowerby, XVII, 1867, Pl. 9, fig. 20.

Doubtfully synonymous:

*Anodon georginæ* Griffith, 1834, p. 595 (index), Pl. 19, fig. 3.

*A. moretonianus* Sowerby undoubtedly is this species. Simpson (1914, p. 1431) is mistaken in placing it with *A. trapesialis.* Sowerby's *moretonianus* is not *A. mortoniana* of Lea.

*A. georginæ* Griffith, from "rivers of Paraguay," also seems to be this species. The figure given *l.c.* is shorter and higher, but the characteristic shape and the radial ribs (although too much emphasized) well agree with it. It is also from a region, where *trigona* is known to occur. For this species, Simpson (1900, p. 927; 1914, p. 1440) creates a separate group.

Simpson makes *Anodonta castelnaudi* Hupé a synonym of *trigona,* but I do not think that this is correct. *A. castelnaudi* lacks the chief characteristic features of *trigona:* the pointed posterior end and the rib upon the posterior slope.

*Type-locality.*—Rivers of the "province Rio Negro." There is now no such province in Brazil, from which country the collections of Spix came.

*Other Localities.*—Amazonas and Bolivia (Von Ihering, 1893, p. 120); Rio Xingu, Pará, Brazil (tributary to lower Amazon) (Von Ihering, 1910, p. 137); Tributaries of Amazon in Bolivia (territory of the Chiquitos and Moxos) (D'Orbigny); Rio Estacamento, Peru (Haas, 1916); Rio Paraguay, San Luis de Caceres, Matto Grosso, Brazil (Von Ihering, 1915, p. 13); Rio Batel and Rio Paraná, Corrientes, Argentina (D'Orbigny).

*New Localities.*—Swamp of Lambaré, Asunción, Paraguay (J. D. Haseman coll., March 31, 1909). One right valve. Headwaters of Rio Paraguay, Santa Rita, Matto Grosso, Brazil (J. D. Haseman coll., June 12, 1909). Two specimens, male and female, with soft parts. Rio Limay, Patagonia, Argentina (W. Israël donor). One specimen.

*Distribution.*—According to Von Ihering (1890): "Everywhere in the Amazonas region, but also in the La Plata up to Corrientes." Simpson gives: Brazil, Ecuador, Peru, Bolivia. The species undoubtedly has a wide distribution, both in the Amazon and the Paraguay-Paraná drainages, but is apparently missing in the upper Paraná. The new locality in Rio Limay in Patagonia (Rio Negro-drainage) considerably extends the southward range.

*Description of Shell.*—Shell rather thick and solid. Outline elongated-ovate, pointed behind, lower margin convex, forming a bluntly projecting angle about its middle. Height 59 to 61 pr. ct. of length according to my specimens (in D'Orbigny's the height is only 54 pr. ct.). Valves not gaping. Dorsal margin gently curved, posterior part almost straight, anterior part descending. Posterior angle of dorsal margin obtuse, but well marked. Anteriorly the dorsal margin forms a very indistinct angle, or passes gradually into the anterior margin. Posterior margin descending obliquely, and almost straight or very gently curved, passing into the posterior part of the lower margin in a very sharp curve, which forms the posterior point of the shell. This point is somewhat elevated above the base-line, since the posterior part of the lower margin slopes upward. This part of the lower margin is almost straight. The lowermost point of the lower margin is a little behind the middle, and in front of it the lower margin changes its direction, running upward and forward, so that this lower point forms a blunt projection. The ascending anterior portion of the lower margin is at first almost straight or

very gently curved, and then it curves up into the anterior margin, which is narrowly rounded. The anterior part of the shell does not appear narrower than the posterior. The greatest height of the shell is a little behind the middle, and anteriorly it rather gradually becomes narrower, while posteriorly it tapers very decidedly to the posterior point. Thus there is also no marked obliquity in the shell. (In the young specimen from Santa Rita the posterior taper is not so strong).

Valves moderately convex, diameter 34 to 36 pr. ct. of length. Beaks not very prominent above hinge-line, located at 18 to 26 pr. ct. of the length. Convexity of the valves greatest over the posterior ridge, least between this ridge and the region of the lower angle of the lower margin. Posterior slope compressed, but hardly any compression at anterior end. A distinct radial rib upon the posterior slope, lying between two radial depressions; sometimes there is a trace of a weak radial rib above it, but generally this is not very distinct. In young specimens the radial rib is indistinct.

Epidermis rather smooth, with irregular concentric lines, which become lamellar upon the posterior slope and towards the ventral margin. No distinct radial sculpture, except some irregular and rather fine scalariform stripes. Color of epidermis normally a very dark green upon the disk, which, however, may turn to brown. The posterior slope may also be dark green, with the shallow grooves brownish, or it may be entirely brown, and in the young specimen it is brown, with the radial rib marked by a rather distinct dark green ray. The disk has no color rays.

Hinge-line practically straight behind the beaks, and in front of them it gently curves down. Ligamental sinus triangular, about as deep as wide, its anterior margin vertical to the hinge-line, or slightly descending backward.

Cavity of shells and beaks moderate. Nacre whitish, more or less iridescent; only in the young specimen with irregular and indistinct radial striæ. Prismatic border rather narrow, subconcentric with margin, and nowhere noticeably widened, except very slightly so in the region of the projecting part of the lower margin. Anterior adductor-scar well impressed, subovate, united above with scar of anterior retractor. Anterior protractor-scar united with or separated from that of the adductor. Posterior adductor-scar faint, subovate, the posterior retractor-scar forming a triangular upper projection of it. Pallial line subconcentric to the margin.

According to Wagner, the height would be 57 pr. ct. of the length.

*Remarks.*—This species has a quite characteristic shape, which varies only slightly, and the most prominent features are the blunt angle of the lower margin,

the anterior position of the beaks, the sub-pointed posterior end, and the radial rib upon the posterior slope. The dark green color of the disk may also be characteristic, but this is liable to fade; in our specimen from Asunción, a much-worn shell, the remnants of the epidermis are brown.

MEASUREMENTS.

| Localities. | Sex. | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|---|
| Santa Rita | ♂ | 36 mm. | 22 mm. =61 pr. ct. of L. | 13 mm. =36 pr. ct. of L. | at 9.5 mm. =26 pr. ct. of L. |
| Do. | ♀ | 62 " | 37 " =59 " | 22 " =35 " | 11 " =18 " |
| Limay | ? | 68 " | 41 " =60 " | 24 " =35 " | 16 " =24 " |
| Asunción | ? | 70 " | 42 " =60 " | 24 " =34 " | 16 " =23 " |
| Spix' figure | | 48 " | 27 " =56 " | | |
| D'Orbigny's figure | | | =54 " | =34 " | |

*Anatomy.*—The soft parts of a young male and a gravid female (collected June 12) are at hand for study.

The typical *Anodontites*-structure is observed. The mantle-connection separating anal and branchial openings is rather long. The branchial opening has extremely fine papillæ. The inner edge of anal and branchial is brown. Palpi of medium size, semicircular, with a short posterior truncation.

In the gravid female the eggs fill the water-tubes of the inner gill, with exception of those near the extreme anterior and posterior ends. The water-tubes are markedly expanded, and the eggs are located in the basal part of the tubes, and only in the inner compartment (ovisac) toward the inner lamina of the gill. No larvæ were seen. The outer gills have the usual structure of alternately thicker and thinner septa, while the septa of the inner gill are more uniform and thicker. The gills of my female are much torn and injured, so that it was not expedient to section them.

### 54. Anodontites hyrioides Ortmann, sp. nov.

*Shells:* Plate XLII, figs. 3, 4, 5.

*Type-locality.*—Rio Tapajos, Santarem, Para, Brazil (J. D. Haseman coll., December 6–12, 1909). *Type-set:* Carn. Mus. Cat. No. 61.5829. Six specimens.

*Characters of the Shell.*—Shell moderately thick, angularly subovate, somewhat oblique, pointed behind, lower margin convex, forming a blunt angle. Height 62 to 73 pr. ct. of the length. Valves not gaping. Dorsal margin practically straight, gently descending in front of the beaks. Posterior angle of dorsal margin obtuse, but quite distinct, wing-like. Anteriorly the dorsal margin forms also a more or less distinct angle, which is obtuse or almost a right angle. Posterior margin obliquely descending, straight, or slightly concave in its upper portion,

curving sharply around into the lower margin, thus forming the posterior point of the shell. This point is only a little elevated above the base-line, since the posterior part of the lower margin runs straight forward, being almost parallel to the dorsal margin (there is some variation in this respect; on the average these two margins diverge very slightly towards the front). From a point at, or slightly behind, the middle of the shell the lower margin changes its direction abruptly, running forward and upward, thus forming a lower blunt angle at about the middle of the shell. The ascending anterior part of the lower margin is first almost straight, but then it passes in a curve into the anterior margin, which is narrowly rounded. The shell appears slightly narrower anteriorly, with the greatest height in the posterior part. The taper of the posterior end is stronger than in *A. trigona*, and thus the shell appears somewhat oblique.

Valves more convex than in *A. trigona*, diameter 38 to 46 pr. ct. of the length. The greatest swelling is towards the beaks, but the beaks are not much elevated above the hinge-line, so that they appear rather depressed. Location of beaks at 27 to 31 pr. ct. of the length of the shell. The convexity of the valves is like that of *A. trigona*, compressed upon the posterior slope, and flattened in front of the posterior ridge. Posterior slope with one or two more or less distinct radial ribs, accompanied by shallow depressions.

Epidermis similar in sculpture to that of *A. trigona*, but more frequently with fine scalariform stripes, chiefly upon the anterior part of the shell, producing the appearance of fine radial sculpture. Color of epidermis from dark or light greenish and yellowish to light or dark brown; one specimen inclines more toward olive-green. Most of the specimens are somewhat concentrically banded with lighter and darker color.

Hinge-line straight behind the beaks, inclining downward in front of them, but very little so in the youngest specimens. Ligamental sinus triangular, shaped like that of *A. trigona*.

Cavity of shell moderate, that of beaks somewhat deeper. Nacre whitish and iridescent, with indistinct radial striæ. Prismatic zone narrow, subconcentric to the margin. Muscle- and mantle-scars as in *A. trigona*.

MEASUREMENTS.

| No. | Length. | Height. | Diameter. | Beaks. | Figured. |
|---|---|---|---|---|---|
| 1.... | 32 mm. | 22 mm. =68 pr. ct. of L. | 14 mm. =44 pr. ct. of L. | at 10 mm. =31 pr. ct. of L. | Pl. XLII, fig. 5. |
| 2.... | 33 " | 24 " =73 " | 14 " =42 " | 9 " =27 " | |
| 3.... | 41 " | 27 " =66 " | 16 " =39 " | 12 " =29 " | |
| 4.... | 42 " | 26 " =62 " | 16 " =38 " | 12 " =29 " | Pl. XLII, fig. 4. |
| 5.... | 42 " | 29 " =69 " | 17 " =40 " | 12 " =29 " | |
| 6.... | 52 " | 33 " =64 " | 24 " =46 " | 14 " =27 " | Pl. XLII, fig. 3. |

*Remarks.*—This species undoubtedly is closely allied to *A. trigona,* and differs chiefly in the dimensions. It might be a local variety of it, but since all six of my specimens are rather uniform in their characters, I take it for a species.

*A. hyrioides* is an *A. trigona,* which is higher and shorter, more inflated, has the outline more sharply angular, and is more oblique. The obliquity is due to the shortening of the shell and the lower position of the posterior point. The outline of our species recalls the shape of the genus *Hyria,* and hence the name.

### 55. Anodontites mortoniana (Lea) (1834).

*Anodonta mortoniana* Lea, Obs. I, 1834, Pl. 13, fig. 37.
*Anodonta weddellii* Hupé, 1857, p. 87, Pl. 17, fig. 5.
*Anodonta lingulata* Hupé, 1857, p. 89, Pl. 18, fig. 1.
*Anodon weddellii* and *lingulata* Sowerby, XVII, 1868, Pl. 20, fig. 80; 1869, Pl. 23, fig. 90.
*Glabaris mortoniana* and *lingulata* Von Ihering, 1893, p. 118, 119.
*Glabaris weddelli, lingulatus,* and *mortonianus* Simpson, 1900, pp. 928, 929.
*Anodontites weddelli, lingulatus,* and *mortonianus* Simpson, 1914, pp. 1442–1445.

*Type-locality.*—River Paraná.

*Other Localities.*—Santa Ana de Chiquitos, Bolivia (Hupé, *weddelli*) (situated about on the divide between the drainages of the Paraguay and the Amazon); Corumbá, Matto Grosso, Brazil (Hupé, *lingulata*); Rio Paraguay (Von Ihering); Lower Paraná (Von Ihering).

*New Localities.*—Mountain creek, Sapucay, Paraguay (S. E. of Asunción) (J. D. Haseman coll., April 5, 1909). One male with soft parts. Headwaters of Rio Paraguay, Santa Rita, Matto Grosso, Brazil (J. D. Haseman coll., June 12, 1909). Two specimens, one a male with soft parts.

*Distribution.*—This species apparently belongs to the Paraguay-drainage and the Rio Paraná below its union with the Paraguay. Von Ihering (1893, p. 114) does not mention any of the forms belonging to this species from the upper Paraná.

*Remarks as to Synonymy.*—The three forms, *mortoniana, weddelli,* and *lingulata,* are kept as separate species by Simpson, but I do not see any essential differences between them.

Hupé admits that *weddelli* is very close to *mortoniana,* but says that it differs in three respects: more swollen shell; narrower and more rounded anterior end; and deeper and larger muscular impressions. These differences are not substantiated by the figures, in fact, we cannot judge as to the first, since no figure showing the obesity is given. According to the measurements in the text, how-

ever, just the opposite is the case, *mortoniana* being more swollen (40 pr. ct.) than *weddelli* (33 pr. ct.). The second difference is not at all correct according to the published figures; and the third apparently is founded only upon the slight indication of the muscle-scars in Lea's figure, and is not essential, anyhow. Besides, Hupé says that the specific difference is supported by the different distribution of the two forms. This again is not evident. *A. weddelli* is from the region of the divide between the Amazon and Paraguay-drainages, and it may very well be from the latter. One of our localities is not very far from it. *A. mortoniana* and *weddelli*, indeed, have been united already by Von Ihering (1893, p. 118).

*A. lingulata* differs from the others only in size and the color of the epidermis. The latter, on the plate, is dark green, while the text says that it is blackish brown, and thus we cannot rely on it. The shell of *lingulata* is more regularly elliptical, but this is not astonishing when we consider the greater age of this shell. It is also from the same general region (upper Paraguay) as *mortoniana* and *weddelli*.

Very similar forms are found also in the Amazon-drainage: *castelnaudi* Hupé, *solidula* Hupé, *amazonensis* Lea, and *elongata* Swainson. But these cannot be united with *mortoniana*, since they all are more elongated.

*Characters of the Shell.*—Shell quite thick and solid. Outline subovate or nearly subelliptical, bluntly pointed behind, lower margin gently convex. Height 61 to 63 pr. ct. of the length, falling, in old specimens, as low as 53 pr. ct. Valves not gaping. Dorsal margin gently convex; the part behind the beaks may be almost straight; in front of the beaks it descends more or less. Posteriorly the dorsal margin forms a blunt angle, or may pass almost insensibly into the posterior margin. There is no distinct angle anteriorly. Posterior margin obliquely descending, more or less convex, curving into the lower margin and forming with it a distinct, but rounded, posterior point of the shell, which is situated at a certain elevation above the base-line, but nearer to the latter than to the line of the upper margin. Lower margin gently and rather regularly curved, ascending somewhat toward the posterior end of the shell, and more strongly so in its anterior part, where it passes in a regular curve into the anterior margin. The anterior part of the shell is only slightly narrower than the posterior, which is widest (highest) a little behind the middle of the shell, and then tapers gently toward the posterior point. The shell is thus transverse, and hardly oblique.

Valves moderately convex, diameter 37 to 41 pr. ct. of the length (*weddelli* is more compressed, 33 pr. ct.). Beaks moderately convex, not very prominent above hinge-line, at 23 to 25 pr. ct. of the length, that is to say, rather anterior. Convexity of valves rather uniform all over the disk, strongest over the posterior ridge, slightly

compressed upon the posterior slope. Posterior slope with one or two blunt radial ribs, which may be more or less distinct, or almost effaced.

Epidermis rather smooth, with irregular concentric lines, which become sublamellar upon the posterior slope and near the lower margin. Traces of radial sculpture are present in the shape of fine scalariform stripes, irregularly disposed upon the shell, and more or less numerous. Color of epidermis brownish or greenish. Upon the disk it may be quite green (dark or light), or it may be darker or lighter brown, with irregular concentric bands of dark green. The posterior slope is (in my specimens) always light brown, with or without greenish tints. No color-rays are seen.

Hinge-line gently curved. In the younger specimens the part behind the beaks is straight; in older ones it is gently curved, and curves down more distinctly under the beaks. Ligamental sinus triangular, about as deep as wide, its anterior margin vertical to the hinge-line.

Cavity of shell and beaks moderate. Nacre whitish, iridescent, only in the youngest specimen with faint traces of radial striæ. Prismatic zone very narrow (comparatively widest in the young), subconcentric to the margin. Anterior adductor-scar well impressed, chiefly in the older shells, subovate, united above with the anterior retractor-scar. Anterior protractor-scar united with, or free from, adductor-scar (this may be different in the right and left valves of the same shell). Posterior adductor-scar less impressed, subovate, the posterior retractor-scar forming an upper triangular projection of it. Pallial line subconcentric to lower margin.

MEASUREMENTS.

| | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|
| Santa Rita... | 52 mm. | 33 mm. = 63 pr. ct. of L. | 20 mm. = 38 pr. ct. of L. | at 13 mm. = 25 pr. ct. of L. |
| Sapucay..... | 54 " | 33 " = 61 " | 20 " = 37 " | 13 " = 24 " |
| Santa Rita... | 69 " | 42 " = 61 " | 28.5 " = 41 " | 16 " = 23 " |

Lea's measurements for *mortoniana* give for the height 53 pr. ct. and for the diameter 40 pr. ct. of the length. Thus the height is less here, but I think this is due to the greater age of this specimen. My largest specimen has a peculiar shape: the posterior end of the shell is drawn down, so that the lower margin is almost straight. This, however, undoubtedly is an individual character, since the growth-lines indicate that the young shell had the normal shape.

The measurements for Hupé's shells are as follows:

| | Length. | Height. | Diameters. |
|---|---|---|---|
| *Weddelli*.................. | 66 mm. | 33 mm. = 53 pr. ct. of L. | 22 mm. = 33 pr. ct. of L. |
| *Lingulata*.................. | 100 " | ? | 40 " = 40 " |

The height of *lingulata* is given as 92 mm., but there surely is a mistake in this statement. According to the figure, it would be 53 pr. ct. of the length.

*Remarks.*—The characters of this species are its rather regular, subovate, or subelliptical, outline, with a blunt point behind, somewhat elevated above the base-line. The shell is not very long and of considerable thickness. The peculiar green in the color of the epidermis is remarkable, but is not always present.

*Anatomy.*—The soft parts of two males are at hand for examination.

The structure is typical of the genus. The papillæ of the branchial opening are very small. The inner edge of the anal and branchial is brown. The palpi are of medium size, semicircular, with a short posterior truncation, forming the posterior margins, which are not united. The septa of the gills are irregularly stronger and weaker.

### 56. Anodontites hasemani Ortmann, sp. nov.

*Shells:* Plate XLII, figs. 6, 7.

*Type-locality.*—Headwaters of the Rio Paraguay, Santa Rita, Matto Grosso, Brazil (J. D. Haseman coll., June 12, 1909). *Type-set:* Carn. Mus. Cat. No. 61.5832. Four specimens, among them two males and a gravid female with soft parts.

*Characters of the Shell.*—Shell moderately thick, outline subovate, narrower in front, broader (higher) behind, not pointed. Height 63 to 67 pr. ct. of the length. Valves not gaping. Dorsal margin gently curved, the part behind the beaks almost straight; anteriorly to the beaks it descends distinctly, and passes into the anterior margin in an indistinct, obtuse angle. At the posterior end the upper margin forms a more distinct, obtuse angle. Posterior margin obliquely descending, gently convex, broadly curving around at the posterior end into the lower margin. The latter is gently curved, and runs forward and upward, being almost straight in the anterior part, finally curving up into the anterior margin. Thus the shell is distinctly narrowed anteriorly, the greatest height being located at about the beginning of the posterior third of the shell, and the shell being somewhat oblique.

Valves rather convex, diameter 42 to 47 pr. ct. of the length. Beaks rather inflated, but only moderately elevated above the hinge-line, located at 27 to 33 pr. ct. of the length. Convexity of valves rather regular, greatest over the posterior ridge, which is indistinct, very slightly compressed upon the posterior slope, without perceptible flattening upon the sides of the disk. Posterior slope with indistinct and faint traces of one or two radial ribs.

Epidermis very slightly shining, with crowded, irregular, fine, subconcentric

lines, becoming lamellar upon the posterior slope and near the lower margin. There are hardly any traces of radial sculpture. Color olive-brown, rather uniform. The smallest specimen has a trace of a dark radial ray upon the posterior slope, otherwise there are no rays, nor indications of growth-rests.

Hinge-line upon the whole gently curved, but the part behind the beaks is practically straight, chiefly in the younger specimens. The part in front is decurved, but in one specimen it distinctly curves up again at the anterior end. Ligamental sinus triangular, hardly as deep as wide, its anterior margin in the largest specimen being vertical, in the others slightly descending backward.

Cavity of shell and beaks rather deep, corresponding to the obesity of the valves. Nacre blueish white, with purple and green iridescence, and with very faint radial striæ in the younger specimens. Prismatic zone quite narrow, subconcentric with the margin. Anterior adductor-scar not very deeply impressed, subovate, united with the scar of the anterior retractor; scar of anterior protractor separated from it more or less completely. Posterior adductor-scar faint, subovate, with an upper triangular process formed by the posterior retractor. Pallial line subconcentric with the margin.

Measurements.

| No. | Sex. | Length. | Height. | Diameter. | Beaks. | Figured. |
|---|---|---|---|---|---|---|
| 1.... | ♂ | 45 mm. | 30 mm. =67 pr. ct. of L. | 19 mm. =42 pr. ct. of L. | at 15 mm. =33 pr. ct. of L. | Pl. XLII, fig. 6. |
| 2.... | ♂ | 57 " | 36 " =63 " | 24 " =42 " | 17 " =32 " | |
| 3.... | ♀ | 62 " | 39 " =63 " | 28 " =45 " | 17 " =27 " | Pl. XLII, fig. 7. |
| 4.... | ? | 66 " | 43 " =65 " | 31 " =47 " | 18 " =27 " | |

*Remarks.*—I cannot find among the described species any one which agrees with the present form. Its chief feature is the broadly rounded posterior end. In this character and in the obliquity it resembles the species of the *patagonica*-group, but it differs from them in the prismatic border, which is narrow. I have placed this species in the *trigona*-group, although it has not the subpointed posterior end, because I could not conveniently place it anywhere else. Of other species, only *A. obtusa* resembles it to a degree, but the latter is somewhat shorter and higher (Height 64 to 69 pr. ct. of L.), and not distinctly oblique, with the upper and lower margins more nearly parallel. Besides, *A. obtusa* has a peculiar color-pattern.

*Anatomy.*—Soft parts of two males and one gravid female at hand.

The structure is of the normal *Anodontites*-type. Papillæ of the branchial opening very small. Gills with the septa well developed. In the gravid female, the inner gills have the usual marsupial structure, with a swelling at the insertion of the septa on the outer (primary) limb of the gill. The water-tubes contain

eggs in their inner compartments, except at the anterior and posterior ends of the gill; the other compartments forming secondary water-tubes. The septa of the ovisacs are somewhat stretched out, and the gill is slightly distended. I was unable to find fully developed larvæ (lasidia?). All eggs are small, round, globular masses of cells (morula-stage), enclosed in a rather tough membrane. In the males no regular alternation of stronger and thinner septa could be noticed, but all septa are rather uniform. The male character, however, has been positively established by microscopic examination (absence of swellings of the septa).

### 5. Group of Anodontites patagonica.

Simpson, 1914, p. 1403.

Shell strongly oblique, subovate or subrotund, not pointed behind. Epidermis more or less shining, but here and there with wrinkles, or covered all over with concentric striæ. Prismatic border rather wide and unequal, being much wider along the anterior lower margin than at the anterior and posterior ends.

The prismatic border forms the most prominent feature of this group. I possess a good number of specimens belonging to the group, and this character is always present, so that we must regard it as of taxonomic value. In addition the shell is here distinctly oblique with a rounded end.

Key to the Forms at Hand.

$a_1$. Shell moderately inflated, diameter generally between 40 and 50 pr. ct. of the length, rarely less. Outline strongly oblique, moderately elongate, sometimes subrotund, height from about 65 to over 80 pr. ct. of length.

- $b_1$. Shell thick, rather more elongated. Nacre whitish............................*A. patagonica.*
- $b_2$. Shell thinner, subrotund or elongated. Nacre often red..............*A. patagonica rubicunda.*

$a_2$. Shell compressed, diameter 36 pr. ct. or less. Outline obliquely ovate, rather elongated, height not over 66 pr. ct.

- $b_1$. Prismatic border wide and unequal. Epidermis shining, striæ not sublamellar....*A. puelchana.*
- $b_2$. Prismatic border narrower, but unequal. Epidermis not very shining, with the striæ often sublamellar..............................................................*A. iheringi.*

### 57. Anodontites patagonica (Lamarck) (1819).

*Anodonta patagonica* Lamarck, 1819, p. 88; Encyclop. Method., II, 1827, p. 147, Pl. 203, fig. 1.

*Anodontites patagonicus* Simpson, 1914, p. 1403.

*Remarks as to Synonymy.*—The synonymy of this species has been given by Simpson, but it needs certain additions and corrections. The following references should be added first of all:

*Anodonta latemarginata* and *uruguayensis* Corsi, 1901, p. 454, 458.

*Anodontites patagonicus* HAAS, 1916, pp. 25, 54.

As we have seen above, *Anodon trapezeum* Spix (1827) should be stricken from the list of synonyms. This is a different species, differing chiefly by the narrow prismatic border. The other references given by Simpson all certainly belong here, and the following names have been used for this species:

*Anodonta latomarginata* LEA (1834).

*Anodonta membranacea* D'ORBIGNY (1843).

*Anodonta solida* KUESTER (1853).

*Anodonta uruguayensis* LEA (1860).

*Anodonta sinuosa* CLESSIN (1873).

*Anodonta serpentina* CLESSIN (1876).

In addition:

*Glabaris bergi* VON IHERING (1893 p. 118), introduced for *sinuosa* Clessin.

But the following forms also belong here as synonyms:

*Anodon crassus* SWAINSON (1823); SIMPSON, 1914, p. 1406. Simpson says: this species is "close to *A. patagonicus*, but I have never seen a specimen of that species quite so elongated or so pentagonal as the figure." The dimensions are: L. 80 mm., H. 52 mm. = 65 pr. ct. of length, Diameter 32 mm. = 40 pr. ct. of length. These figures agree well with the dimensions of my series of specimens from San Isidro, some of which are even more elongated (height falling as low as 60 pr. ct.

*Anodonta wymani* LEA (1860); SIMPSON, 1914, p. 1407, who says: "More elongated and more richly colored than *A. patagonicus*." The elongation is even greater than in *A. crassus* (Height = 63 pr. ct. of length), but it still remains within the limits of variation of my set from San Isidro. Some of the latter undoubtedly are *wymani* in every respect. The color is no reliable character, being very variable in *A. patagonica*.

I am unable to form an opinion as to *A. sirionos* D'Orbigny (1835) (= *ferrarisi* D'Orbigny, 1835). It certainly is nearly related to *A. patagonica*, but, according to the original description, is distinguished by a rough and concentrically and lamellarly striate epidermis. I have no specimens corresponding to this form.

*Type-locality.*—Rio de la Plata and Patagonia.

*Other Localities.*—Rivers of Uruguay between Montevideo and Buenos Aires (D'Orbigny, *membranacea*); Rio Miguelete, Montevideo, Uruguay (Haas); Arroyo S. José, Uruguay (N. W. of Montevideo) (Corsi, *uruguayensis*); Uruguay River (Lea, *uruguayensis, wymani*); Rio de la Plata (Haas); Rio de la Plata, Buenos Aires, Argentina (D'Orbigny, *membranacea*); Rio Paraná (Lea, *latomarginata*);

Rio Paraná up to sixty miles above Corrientes, Argentina (D'Orbigny, *membranacea*).

*Localities Represented in the Carnegie Museum.*—Rio Paraná (Hartman collection). One specimen. In pond along banks of Rio Negro, Santa Isabel, Uruguay (J. D. Haseman coll., February 11, 1909). One specimen. Arroyo Miguelete, Montevideo, Uruguay (J. D. Haseman coll., February 17, 1909). One specimen. Rio de la Plata, San Isidro, 20 km. N. of Buenos Aires, Argentina (A. Windhausen coll., January, 1917). Twenty specimens with soft parts, males and females.

*Distribution.*—La Plata system, from the mouth near Buenos Aires up the Paraná to the province of Corrientes in Argentina; also in the Rio Uruguay and the Rio Negro, and the tributaries of the La Plata in the Banda Oriental of Uruguay.

*Characters of the Shell.*—Shell rather large (length up to 100 mm. and over), rather thick and solid. Outline very oblique, subovate, longer or shorter, height 60 to 74 pr. ct. of the length. Young shells probably higher and more subrotund, according to the growth lines in older shells, but such shells have not been observed (the smallest shell is 75 mm. long). Valves not gaping. Dorsal margin straight or gently curved, generally with a well marked, blunt posterior angle, while the anterior angle is less distinct, often quite rounded. Posterior margin obliquely descending, generally almost straight, rarely gently convex, and very rarely a little concave, curving broadly and regularly into the posterior lower margin, generally forming no angle or posterior point, but sometimes with a trace of it. The anterior part of the ventral margin is strongly ascending and always more or less gently curved, and often almost straight, curving up into the anterior margin, which is narrowly rounded. Thus the anterior end of the shell appears much narrower than the broadly rounded posterior part, rendering the shell decidedly oblique.

Valves moderately swollen, diameter 38 to 44 pr. ct. of length, rarely slightly less. Beaks slightly convex, and only little elevated above the hinge-line, located at 28 to 34 pr. ct. of the length. Disk moderately convex, more strongly so over the middle part and the posterior ridge; posteriorly compressed. Posterior ridge very indistinct, but often there is a radial rib upon the posterior slope, sometimes accompanied by a furrow. The anterior end of the shell is also slightly compressed.

Epidermis rather smooth, but with fine, irregular, concentric striæ, almost effaced in the middle of the disk and toward the beaks, more distinct toward the margins, where they may become sublamellar. Very fine radial, oblique, or reticulated wrinkles may be present between the striæ. Scalariform radial stripes are generally absent, but in some specimens slight traces of them are seen. Color of epidermis dark greenish-olive to various shades of brown. Generally there is

more green toward the beaks, more brown toward the margins, but the green may extend over nearly the whole shell, or may be absent. Upon the posterior slope there may be a few indistinct, dark green rays, and the green color near the beaks often has a mottled character, consisting of irregular, darker and lighter concentric bands, and, rarely, of indistinct radial rays or blotches. In some specimens, the anterior and posterior parts of the shell are different in shade, the posterior being darker (more greenish), the two shades being separated rather sharply by a radial line. Growth-rests few, and rarely distinct.

Hinge-line nearly straight, or very gently curved behind the beaks. In front of them it descends more or less distinctly, and may ascend again at the anterior extremity, thus becoming slightly sinuate. Ligamental sinus triangular, somewhat variable, but generally deeper than wide, chiefly in older shells, its anterior margin mostly vertical to the hinge-line, and its lower point curved more or less forward. Often the anterior margin has an S-shaped curve.

Cavity of shell and beaks moderate. Nacre whitish, iridescent, but none of my specimens has red tints. Radial striations are present, but indistinct in older shells. Prismatic border broad, unequal in width, broadest along the ascending anterior lower margin, narrower in front, and narrowing rather suddenly at the beginning of the posterior part of the lower margin. Its color is grayish or yellowish green, or grayish or yellowish white. Anterior adductor-scar well impressed, subelliptical, united above with that of the retractor, or sometimes incompletely separated. Anterior protractor-scar generally well separated from the adductor-scar. Posterior adductor-scar less impressed, subovate, with an upper triangular projection formed by the posterior retractor-scar. Pallial line distinct, subconcentric with the shell-margin, and thus more closely approaching the prismatic border in the anterior part of the lower margin than before and behind it. No dorsal scars.

MEASUREMENTS.

| Locality. | No. | Sex. | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|---|---|
| San Isidro....... | 19 | ♂ | 75 mm. | 53 mm. =71 pr. ct. of L. | 30 mm. =40 pr. ct. of L. | at 25 mm. =33 pr. ct. of L. |
| Do. ....... | 14 | ♂ | 87 " | 56 " =64 " | 38 " =44 " | 29 " =33 " |
| Do. ....... | 10 | ♀ | 89 " | 62.5 " =70 " | 39 " =44 " | 25 " =28 " |
| Do. ....... | 2 | ♀ | 91 " | 67 " =74 " | 36.5 " =40 " | 27 " =30 " |
| Do. ....... | 20 | ♀ | 93.5 " | 56 " =60 " | 39 " =42 " | 26 " =28 " |
| Do. ....... | 8 | ♂ | 103 " | 66.5 " =65 " | 37 " =36 " | 31 " =30 " |
| Montevideo..... | | ? | 77 " | 51 " =66 " | 30 " =39 " | 26 " =34 " |
| Santa Isabel..... | | ? | 98 " | 67 " =68 " | 42 " =43 " | 33 " =34 " |

PREVIOUS MEASUREMENTS.

| | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|
| D'Orbigny (*membranacea*).... | 90 " | =73 " | =33 " | |
| Simpson (*patagonica*)........ | 81 " | 59 " =73 " | 32 " =40 " | |
| Do. ........ | 87 " | 57 " =66 " | 37 " =43 " | |
| Simpson (*crassa*)............ | 80 " | 52 " =65 " | 32 " =40 " | |
| Simpson (*wymani*).......... | 80 " | 50 " =63 " | 30 " =38 " | |
| Lea (figure of *wymani*)....... | 87 " | 55 " =63 " | 33 " =38 " | |

All of these previous measurements fall within the range of variation of my series, with the exception of the diameter given by D'Orbigny, which is somewhat lower (33 pr. ct.) than any of my figures (lowest 36 pr. ct.).

*Remarks.*—This species is very variable in shape, being sometimes higher, sometimes more elongated. There is no indication that the shape is connected with sex. Since no very young specimens are at hand, and never have been observed, we do not positively know anything about their shape, but from the growth-lines of the old specimens it is seen that the young shell generally must have been comparatively higher: the shell grows, with advancing age, more in the direction of the posterior end, so that the longitudinal diameter increases more than the vertical.

There is no doubt in my mind that *A. crassa* and *wymani* belong here, and that they represent specimens which are a little more elongated than the average; but among the set from San Isidro, I have specimens which represent even greater extremes than these.

*A. patagonica* is rather thick and solid, but varies also in this respect. The specimen from Montevideo at hand is not quite as thick as the others, but agrees with them in other respects, being also rather elongated. Just such specimens induce me to regard the next form (*rubicunda*) as a variety of *patagonica*.

*Anatomy.*—Soft parts of eight males, one barren, and eleven gravid females have been investigated. The breeding season is January.

The anatomy of *latomarginata* and *wymani* has been previously described by Lea (Obs. X, 1863, pp. 391, 394) as far as the superficial characters of the gills, the palpi, and the branchial and anal openings are concerned.

Von Ihering (1891, p. 480) describes the eggs and lasidia of *Glabaris wymani*, the former being 0.09 mm. in diameter, the latter 0.086 mm. long. However, since he says that his specimens are from Rio Camaquam, I am not sure that they have been properly identified. They might belong to *A. iheringi* (Clessin).

Anal opening entirely open, separated from the branchial by a connection of the mantle-margins. Inner edge of anal smooth above, very finely crenulated near the lower end. Branchial opening with small papillæ. Palpi nearly semicircular, longer than high, behind abruptly truncated, the posterior margins connected at base.

Gills rather wide, the inner much wider than the outer in front, its anterior end immediately behind the palpi, and attached along the whole space between the palpi and the anterior end of the outer gill. Inner lamina of inner gill entirely connected with abdominal sac. Septa of the gills well developed. In the non-

marsupial gills they are irregularly alternating. In the female, the *inner* gill is *marsupial* nearly throughout its whole length. The septa are stronger and equal, having near the outer lamina a swelling indicating ridges projecting into the lumen of the water-tubes. When charged the egg-masses occupy only the inner compartments, forming ovisacs, which are somewhat distended, while the outer compartments do not change, and apparently serve as (secondary) water-tubes. Eggs very small. I did not see any larvæ. Even in a specimen which had the gills only partially charged (anteriorly), and which might have been discharging, the eggs consisted only of a globular mass of cells enclosed in a membrance.

### 57*a*. Anodontites patagonica rubicunda (Lea) (1860).

*Diagram of soft parts:* Text-fig. 3, p. 458.

*Section of gills:* Plate XLVIII, fig. 8.

*Anodonta rubicunda* Lea, Obs. X, 1863, Pl. 46, fig. 299; Corsi, 1901, p. 455.
*Anodonta pazii* Lea (1866) Obs. XII, 1869, Pl. 36, fig. 87.
*Anodon rubicundus* Sowerby, XVII, 1870, Pl. 30, fig. 118.
*Glabaris rubicunda* Pilsbry & Rush, 1896, p. 81; Simpson, 1900, p. 913.
*Glabaris latomarginatus felix* Pilsbry, 1896, p. 563, Pl. 26, fig. 8.
*Glabaris pazii* Simpson, 1900, p. 918.
*Anodontites latomarginata felix* Simpson, 1914, p. 1405.
*Anodontites pazi* Simpson, 1914, p. 1408; Haas, 1916, pp. 30, 55.
*Anodontites rubicundus* Simpson, 1914, p. 1409.

*Type-locality.*—Uruguay River.

*Other Localities.*—Rio de la Plata, Colonia, Uruguay (Pilsbry & Rush, *rubicunda*) (Pilsbry, *felix*); Uruguay River, Paysandu, Uruguay (Pilsbry & Rush); Uruguay River, Salto Oriental, Uruguay (Haas).

*New Localities.*—Rio Uruguay (in mud), Uruguayana, Rio Grande do Sul, Brazil (J. D. Haseman, February 5, 1909). Twelve specimens, eleven of them with soft parts, males and females. In pond along banks of Rio Negro, Santa Isabel, Uruguay (J. D. Haseman coll., February 11, 1909). Three specimens. Rio Ibicuhy, Cacequy, Rio Grande do Sul, Brazil (J. D. Haseman coll., February 1, 1909). One male with soft parts. Rio Cacequy (in sand), Cacequy, Rio Grande do Sul, Brazil (J. D. Haseman coll., February 2, 1909). One female with soft parts.

*Distribution.*—Known only from the Uruguay and the Rio de la Plata below the mouth of the Uruguay, and from the Rio Negro in Uruguay and Rios Ibicuhy and Cacequy in Rio Grande do Sul, these being tributaries of the Uruguay.

Closely allied to *A. patagonica*, but differing in being somewhat smaller (maximum length 84 mm.), with a thinner shell. The outline of the shell is more nearly and more frequently subrotund, and the diameter ranges higher (up to 50 pr. ct.). The nacre very often, but not always, has reddish or purple tints.

MEASUREMENTS (SPECIMENS FROM URUGUAYANA).

| No. | Sex. | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|---|
| 1....... | ♂ | 47.5 mm. | 36.5 mm. =77 pr. ct. of L. | 19.5 mm. =41 pr. ct. of L. | at 17 mm. =36 pr. ct. of L. |
| *b*....... | ♀ | 53 " | 44.5 " =84 " | 24.5 " =46 " | 19 " =36 " |
| *r*2...... | ♀ | 59 " | 42 " =71 " | 22 " =37 " | 20 " =34 " |
| *d*....... | ♀ | 62 " | 50 " =81 " | 31 " =50 " | 24 " =39 " |
| 3....... | ♂ | 66 " | 49 " =74 " | 27 " =41 " | 22 " =33 " |
| *e*....... | ♀ | 75 " | 58 " =77 " | 33 " =44 " | 22.5 " =30 " |
| 4....... | ♀ | 84 " | 59 " =70 " | 35 " =42 " | 29 " =35 " |

OLDER MEASUREMENTS.

| | | | | |
|---|---|---|---|---|
| Simpson, *rubicunda*. | 59 " | 51 " =86 " | 30 " =51 " (Type) | |
| Do. | 77 " | 61 " =79 " | 36 " =48 " | |
| Simpson, *pazi*..... | 60 " | 43 " =72 " | 26 " =43 " (Type) | |
| Do. ..... | 53 " | 38 " =72 " | 26 " =49 " | |
| Pilsbry, *felix*...... | 49 " | 35 " =71 " | 18 " =37 " | |
| Do. ...... | 53 " | 38 " =72 " | 20.5 " =39 " | |

*Remarks.*—All the previous measurements fall within the range of variation of my specimens, only the type of Lea's *rubicunda* is higher, shorter, and more swollen than any of my specimens. Thus we are to regard the type of *rubicunda* as an exceptional specimen, which is also peculiar in the fact that the posterior margin forms nearly a right angle with the upper margin. All these peculiar features are correlated, however. The *normal* type of this form is better represented by Lea's *pazi*; yet there are specimen in my material which distinctly approach the *rubicunda*-type.

It is unknown whether this form ever reaches the size of *A. patagonica*, and in the absence of young specimens of the latter it is impossible to compare them directly. But it seems that the more nearly rotund shape is rather a juvenile character, although there are young specimens in my material which are more elongated. From the measurements given it is seen that the height ranges from 70 to 84 pr. ct. in my material, reaching 86 pr. ct. in Lea's type of *rubicunda*, while it ranges from 60 to 74 pr. ct. in *patagonica*. The diameter in *rubicunda* is from 37 to 50 pr. ct. (51 pr. ct. in the type), while in *patagonica* it is from 36 to 44 pr. ct.

Clearly height and diameter are correlated, a shorter and higher shell being also more swollen than a more elongate one. The slight difference in the location of the beaks (30 to 39 pr. ct. in *rubicunda*, 28 to 34 pr. ct. in *patagonica*) is also connected with this. Finally it may be that all these differences in the shape are connected with age, and this may be true also of the thickness of the shell. How-

ever, my largest specimens of *rubicunda* differ in this from the smallest specimens of *patagonica* (of about the same size), but not very strikingly.

Much stress has been laid in the original descriptions of *A. rubicunda* and *pazi* upon the red color of the nacre. According to my material this is extremely variable. In some specimens the color does not differ from that of *A. patagonica*, being whitish. In others it is more or less tinted with red or purple, and then also, generally, the prismatic border is dull purplish gray. But this also is not a constant character.

Pilsbry's *felix* is said to be characterized by its light, yellow-green epidermis, which has radiating or irregularly zig-zag lines of green. I see traces of this in some of my specimens from Uruguayana and Santa Isabel, and there are also here and there black markings on the inside along the pallial line and near the muscle-scars (and elsewhere), mentioned by Pilsbry as occurring in *felix*. These are individual characters.

The epidermis of *rubicunda* is much as in *patagonica, i.e.*, somewhat lamellar near the margins, smoother in the middle. Scalariform stripes are sometimes indicated, but are mostly absent. The color in younger specimens is generally dark green all over the shell, but a few are brownish. Those with intense red tints on the inside are sometimes a little reddish brown on the outside. The largest specimen in the color of the epidermis is much like *patagonica*, brownish, inclining to olive toward the beaks.

D'Orbigny says of *patagonica* (*membranacea*) that it is very variable; that it is larger and thicker in the larger rivers; more elongated in lakes; and that it becomes reddish on the inside in small rivers. My specimens support the latter observation, for they all are, so far as they may be called *rubicunda* and have red nacre, from comparatively small rivers (Rio Negro, upper Uruguay, Ibicuhy, and Cacequy). But, of course, this requires further study and more material.

*Anatomy:* The soft parts of six males and seven females are at hand, one of the latter gravid (February 5).

The anatomy of two males of *pazi* has been described by Lea, but only the major features have been mentioned. According to my material the soft parts agree entirely with those of the typical *patagonica*. In the gravid female the swelling of the charged *marsupium* is not considerable. The small eggs hang loosely together, and easily fall apart. No fully developed larvæ could be found. A diagrammatic figure of the soft parts is given in text-figure 3 (p. 458), and the structure of the gills of a barren female in cross-section is shown on Pl. XLVIII, fig. 8.

58. ANODONTITES PUELCHANA (D'Orbigny) (1835).

*Anodonta puelchana* D'ORBIGNY, 1843, p. 620, Pl. 79, figs. 7–9.
*Glabaris puelchanus* SIMPSON, 1900, p. 921.
*Anodontites puelchanus* PILSBRY, 1911, p. 609.

Simpson (1914, p. 1420) unites this with *A. limnoica* D'Orbigny, but the latter has a very narrow prismatic border. According to my observations, the width of this border is a very constant and important character. Simpson places this species in the group of *crispata*; but there is not the slightest trace of the characteristic sculpture of the epidermis of this group. That Simpson has entirely misunderstood this species is shown by the fact that he unites *A. obtusula* Hupé with it. The latter is a species which is not at all oblique.

*Type-locality.*—Marsh of San Xavier on Rio Negro, above Carmen de Patagones, Argentina.

*Additional Locality.*—Twelve leagues from Chichinal, Patagonia (on Rio Negro) (Pilsbry).

*New Locality.*—Rio Limay, Patagonia (drainage of Rio Negro) (W. Israël donor). Two specimens with soft parts, male and female.

*Distribution.*—Known only from the Rio Negro-drainage in Patagonia. Von Ihering (1893, p. 118) lists it as from the lower Paraná, but without substantiating this record.

According to D'Orbigny's description and figure, this species is an obliquely-ovate, much compressed, thin shell, with shining epidermis, and wide prismatic border. It is surely related to *patagonica*, being, however, not so high and more elongated (height 57 to 65 pr. ct. of length, while patagonica has the height 60 to 84 pr. ct. The diameter is about 31 pr. ct. while in *patagonica* it never falls below 33 pr. ct. and only rarely below 40 pr. ct.

The two specimens before me have the wide prismatic border, somewhat unequal in width; the nacre is whitish with pinkish shades (D'Orbigny says "blanc-rose"). The epidermis is highly polished and shining; there are some concentric grooves, but the fine concentric striæ are missing upon the greater part of the disk, and are only slightly developed near the margins. There are, chiefly in my larger specimen, a few scalariform stripes upon the anterior part of the shell, consisting of radial bands of short, concentric wrinkles. Upon the posterior slope there is an indication of a radial rib. Color of epidermis greenish brown, more greenish toward the beaks, more brownish toward the margins, with very indistinct traces of green rays upon the posterior slope.

MEASUREMENTS.

| No. | Sex. | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|---|
| 1.... | ♂ | 40 mm. | 26 mm. = 65 pr. ct. of L. | 12.5 mm. = 31 pr. ct. of L. | at 13.5 mm. = 34 pr. ct. of L. |
| 2.... | ♂ | 65 " | 40 " = 62 " | 20 " = 31 " | 21 " = 32 " |
| D'Orbigny. | | 60 " | = 57 " | = 31 " | |

*Anatomy.*—The soft parts of the male and female at hand are not in good condition, the female being the better of the two. The usual structure of the genus, however, could be made out, and no special features require mention.

59. ANODONTITES IHERINGI (Clessin) (1882).

*Shells:* Plate XLII, fig. 8; Plate XLIII, fig. 1; Plate XLIV, fig. 1.

*Anodonta iheringi* CLESSIN, Malakazoöl. Blætt., V, 1882, p. 191, Pl. 4, fig. 5.
*Glabaris iheringi* SIMPSON, 1900, p. 919.
*Anodontites sirionos iheringi* SIMPSON, 1914, p. 1408.

*Type-locality.*—Taguara del Mundo Novo, Rio Grande do Sul, Brazil (system of Rio Guahyba, N. E. of Porto Alegre).

*New Localities.*—Rio Jacuhy, Cachoeira, Rio Grande do Sul, Brazil (J. D. Haseman coll., January 26, 1909). One young specimen, with soft parts, sex not determined. Rio Vaccahy-Mirim, Santa Maria, Rio Grande do Sul, Brazil (J. D. Haseman coll., January 29, 1909). Three specimens, with soft parts, two males and a female.

*Distribution.*—Guahyba-drainage in Rio Grande do Sul.

This species very closely resembles *A. patagonica*, but is more elongated and oblique, so that in outline it is still more like *A. puelchana*. To the latter species it is related also in the more compressed shell.

The shell is rather thin, of medium size. The outline is obliquely ovate, narrower anteriorly, broader (higher) posteriorly. The lower margin ascends in its anterior portion, and may be gently curved or nearly straight. Valves gently convex, rather compressed. The prismatic border is not so wide as in *patagonica* and *puelchana*, but it is of the same general character, being wider along the anterior lower margin. It is of a grayish green color. The nacre is silvery white, highly iridescent, often greenish or grayish discolored. Ligamental sinus about as deep as wide, its anterior margin vertical, with the point bending forward.

The chief difference from *patagonica*, and especially from *puelchana*, is in the texture and color of the epidermis. The latter is brownish or brownish olive, not very shining, covered with close, subconcentric striæ, sublamellar near the margins. Scalariform stripes are distinct upon the anterior half of the shell,

consisting of radial bands of short, subconcentric wrinkles. These stripes may also be seen upon the posterior section of the shell, but less frequently and less distinctly.

MEASUREMENTS.

| Location. | No. | Sex. | Length. | Height. | Diameter. | Beaks. | Figured. |
|---|---|---|---|---|---|---|---|
| Cachoeira . . . | | ? | 22.5 mm. | 14.5mm. =64 pr.ct. of L. | 8 mm. =35 pr. ct. of L. | at 6.5 mm. =29 pr. ct. of L. | |
| Santa Maria. | 1 | ♂ | 53 " | 35 " =66 " | 18 " =34 " | 17 " =32 " | Pl. XLII, fig. 8. |
| Do. . | 2 | ♂ | 56 " | 36.5 " =65 " | 20 " =36 " | 18 " =32 " | Pl. XLIII, fig. 1. |
| Do. . | 3 | ♀ | 69 " | 43 " =62 " | 25 " =36 " | 21.5 " =31 " | Pl. XLIV, fig. 1. |

Simpson's measurements are: Length 61 mm.; Height 39 mm. = 64 pr. ct. of L.; Diameter 22 mm. = 36 pr. ct. of Length.

*Remarks.*—The original description and that given by Simpson are scarcely sufficient to enable the species to be recognized, but none of the characters given conflict with those exhibited by my specimens, and the measurements apply very well. Since the original *A. iheringi* comes also from the same river-system (Guahyba) as my specimens, I have no doubt that we are dealing with this species.

*Anatomy.*—Two males, and one female are at hand for study.

The soft parts are absolutely identical with those of *A. patagonica.*

### 6. GROUP OF *Anodontites trapesialis.*

Shell strongly oblique, subovate to subtrapezoidal, narrowly rounded, or bluntly pointed behind. Epidermis shining, only here and there, and not always, with scalariform radial bands of wrinkles. Prismatic border narrow and of equal width.

A rather well defined group, distinguished also by the large and comparatively thin shell: the largest species of the genus belong here. Usually we discover that the valves are gaping anteriorly, and sometimes also posteriorly. Whether this is connected with the anatomical structure, or with habits, is not known. There is hardly a question that the genus *Leila* is descended from forms belonging to this group.

Von Ihering has given a partial key to the species (1890, p. 157), which I have used to great advantage. But great difficulties arise in distinguishing the species, and young individuals are often very hard to correlate with older ones. Although I possess good material representing this group, it includes only comparatively few forms, so that I am unable to form a definite opinion as to those which are not represented. I treat my specimens here under the names to which they seem to belong, without going into detail as to their affinities and relationships.

60*a*. Anodontites trapesialis anserina (Spix) (1827).

Simpson, 1914, p. 1430.

*New Locality.*—Rio Paraguay, Corumbá, Matto Grosso, Brazil (H. H. Smith coll.). Three right valves.

I do not propose to go into a lengthy discussion of this form. I merely desire to say that two of my specimens agree very well in shape and size, with the figures given by Spix, while the third more resembles Sowerby's figure (Pl. 31, fig. 125). They vary slightly among themselves in the degree of the taper of the anterior end. In all of them the hinge-line is very gently curved, but not sinuous (as in *A. exotica*).

The original *A. anserina* is from the Rio Solimoes, in the province of Amazonas.

60*b*. Anodontites trapesialis scripta (Sowerby) (1867).

Simpson, 1914, p. 1430.

Simpson unites with this *A. bahiensis* Kuester (Von Ihering, 1890, pp. 153, 157; 1893, p. 115; 1910, p. 138).

No exact localities are known. *A. bahiensis*, which is given from Bahia, is not from that region, but, according to Von Ihering (1910) from the upper Amazon and Ecuador. Von Ihering (1890, p. 152) thinks, on the other hand, that *scripta* is identical with *exotica*.

*New Locality.*—Rio Ribeira, Iguapé, São Paulo, Brazil (Haseman collection, collected by Richardo Krone). Two odd valves, right and left.

My specimens agree well with Sowerby's (Pl. 4, fig. 9) in shape and size. One of them has the characteristic zig-zag black markings on the inside, while in the other one these are found only near the posterior adductor-scar. However, the color of the epidermis in both is not brownish, but green, darker upon the posterior slope. Very obscure green rays are seen on some parts of the disk. Since Simpson says that the color of the epidermis varies to the "ordinary" (green) color, I do not think that this prevents the union of our specimens with *scripta*. My left valve has anteriorly two short scalariform stripes, barely visible; in the right valve such are entirely absent.

Measurements.

| | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|
| Left..... | 154 mm. | 93 mm. = 60 pr. ct. of L. | 50 mm. = 32 pr. ct. of L. | at 61 mm. = 40 pr. ct. of L. |
| Right.... | 160 " | 96 " = 60 " | 48 " = 30 " | 60 " = 38 " |

61. Anodontites moricandi (Lea) (1860).

Simpson, 1914, p. 1439.

Synonym:

*Anodonta hertwigi* Von Ihering, 1890, p. 150, Pl. 9, fig. 7; 1910, p. 138.

Von Ihering (1910, p. 138) regards *Anodon radiatus* Spix (1827) as the young of this species, and in that case, of course, the specific name *radiata* should supersede that of *moricandi*. However, I am not convinced that this is right, for those of our specimens which are nearly of the size of Spix' original, do not agree with it in shape. They do not have the strongly convex lower margin, and the relative dimensions, chiefly the height, also do not fit. According to Von Ihering, the measurements of *radiata* are: Length 70 mm.; Height 36 mm. = 51 pr. ct. of L.; Diameter 20 mm. = 29 pr. ct. L.

*Type-locality.*—Bahia, Brazil.

*Other Localities.*—Rio São Francisco, Villa Nova, Sergipe, Brazil (Von Ihering); Rio Paraguassú, Bahia, Brazil (Von Ihering); Rio Pardo, Bahia, Brazil (Von Ihering).

*New Locality.*—In a lagoon of Rio Parahyba, Campos, Rio de Janeiro, Brazil (J. D. Haseman coll., June 14, 1908). Six specimens.

*Distribution.*—Streams of eastern Brazil, from mouth of Rio São Francisco in Sergipe southward to Rio Parahyba in Rio de Janeiro. Known from the rivers São Francisco, Paraguassú, Pardo, and Parahyba.

My specimens agree well with this species. What is regarded as one of its essential characters, the flattening of the disk on the sides, is developed only in larger specimens. My largest specimen shows it distinctly, although not as strikingly as Lea's figure. In the smaller ones this is less evident, but even in these the greatest diameter of the shell is in about the middle of the length, not much behind the beaks.

Measurements.

| Length. | Height. | Diameter. | Beaks. | |
|---|---|---|---|---|
| 30.5 mm. | 17 mm. = 56 pr. ct. of L. | 10 mm. = 32 pr. ct. of L. | at 11 mm. = 36 pr. ct. of L. | |
| 49 " | 28 " = 57 " | 17.5 " = 36 " | 18 " = 37 " | |
| 75 " | 45 " = 60 " | 25 " = 33 " | 24 " = 32 " | |
| 78 " | 44.5 " = 57 " | 23.5 " = 30 " | 25.5 " = 33 " | |
| 89 " | 50.5 " = 57 " | 25.5 " = 29 " | 29 " = 33 " | |
| 98 " | 57 " = 58 " | 30 " = 31 " | 34 " = 35 " | |
| 104 " | 61 " = 59 " | 32 " = 31 " | 30 " = 29 " | (Lea's fig.) |
| 117 " | 70 " = 60 " | 35 " = 30 " | | (Simpson) |
| 110 " | 62 " = 56 " | less than 34 " | | (*hertwigi*) |

62. Anodontites riograndensis (Von Ihering) (1890).

*Shells:* Plate XLIII, figs. 2, 3; Plate XLIV, fig. 2.

*Anodonta riograndensis* Von Ihering, 1890, pp. 154, 158.
*Glabaris riograndensis* Von Ihering, 1893, pp. 118, 119.
*Anodonta exotica* Corsi (*non* Lamarck), 1901, p. 456, fig. 37.

It is quite possible that *A. exotica* of D'Orbigny (*non* Lamarck) represents chiefly this species. However, on account of the great diameter (44 pr. ct. of length) of the specimen measured, this appears to be rather *A. forbesiana*. Since there is no figure given, D'Orbigny's species remains doubtful. The figure of *A. exotica* given by Corsi certainly in this species.

*Type-locality.*—Rio Grande do Sul, Brazil.

*Other Localities.*—Rio Paraguay (Von Ihering); Lower Paraná and La Plata Rivers (Von Ihering); Rio Uruguay (Von Ihering); Department of Colonia, Uruguay (Corsi); Arroyo Mendoza, Department Florida, Uruguay (Corsi); Montevideo, Uruguay (Von Ihering).

*New Localities.*—In a pond along banks of the Rio Negro, Santa Isabel, Uruguay (J. D. Haseman coll., February 11, 1909). Two males with soft parts, four odd right vales. Headwaters of Rio Paraguay, Santa Rita, Matto Grosso, Brazil (J. D. Haseman coll., June 12, 1909). One specimen. Rio de la Plata, San Isidro, 20 km. N. of Buenos Aires, Argentina (A. Windhausen coll., January 1917). Three specimens, male, and gravid females, with soft parts.

*Distribution.*—La Plata-drainage from Buenos Aires up to the headwaters of the Paraguay in Matto Grosso; in the Uruguay and its tributaries; and also in streams of the Banda Oriental to Florida and Montevideo. According to Von Ihering occurring also in the Rio Grande do Sul, but exact localities not known.

*Characters of Shell.*—Shell large (length up to 130 mm. and over), moderately and variably solid, but never thin. Valves distinctly gaping anteriorly, slightly so posteriorly. Outline subtrapezoidal, rather elongated, height 54 to 63 pr. ct. of the length, distinctly oblique. Upper margin gently curved or nearly straight, forming a more or less distinct, obtuse angle with the posterior margin, and also with the anterior margin. Sometimes in old specimens these angles are obliterated. Posterior margin obliquely descending, not very steep, straight, or gently convex, curving around into the posterior lower margin, forming a blunt posterior point of the shell, situated a little above the base-line. Lower margin convex, but ascending in its anterior part, and becoming here nearly straight for a distance just in front of the middle; then curving up into the anterior margin. Thus the shell is distinctly narrower anteriorly, and this produces the oblique shape. Often

this shape is obscured on an external view on account of the elevation of the beaks, but it is best seen from the inside, when the ligament behind the beaks is placed horizontally.

Valves moderately convex, somewhat flattened upon the sides, greatest diameter 34 to 40 pr. ct. of the length, located upon the posterior ridge, some distance behind the beaks. Posterior ridge indistinct. Posterior slope compressed, sometimes with traces of a radial ridge and furrow. Beaks a little inflated and a little elevated above the hinge-line, their tips located at 29 to 33 pr. ct. of the length.

Epidermis rather smooth and shining. Irregular subconcentric ridges are present, but no lamelliform striæ, except on the posterior slope, where they may be more or less distinct, and rather crowded. Upon the smooth part of the disk there are often a few radial scalariform stripes, consisting of short subconcentric wrinkles. But these may be entirely missing. Color of epidermis prevailingly green, but shading into brown, often with concentric bands of darker or lighter green and brown. Green rays may be present or absent; when present, they are best developed on and just in front of the posterior ridge. Posterior slope generally dark green to blackish, often with a few black rays.

Hinge-line nearly straight behind the beaks, but gently and distinctly curving down anteriorly, so that the whole hinge-line appears as gently curved. A trace of a slight sinuation may be observed in a very obscure elevation of the hinge-line at its anterior end, but generally this is not the case. Ligamental sinus broad and deep, in older specimens deeper than in younger ones, its anterior margin running obliquely backward in young individuals, but being vertical in old ones. Sometimes the anterior margin is curved, the lower point turning forwards.

Cavity of shell and beaks moderate, corresponding to the obesity of the shell. Nacre whitish and iridescent, often much discolored, and quite frequently there are fine, irregular, subconcentric, waved, or zig-zag, black lines inside of the shell, chiefly near the pallial line. Faint radial striations may be present in young specimens. Prismatic border narrow or very narrow, subequal in width, grayish green or brownish green.

Anterior adductor-scar slightly impressed, irregular in outline, with an upper process representing the anterior retractor-scar. Anterior protractor-scar separated from adductor-scar. Posterior adductor-scar faint and often indistinct, the posterior retractor forming an upper triangular process thereof. No dorsal scars. Pallial line subconcentric to the margin.

*Remarks.*—The height is given by Von Ihering as from 49 to 57 pr. ct. of length, thus being less on the average than in my specimens; but I think this is due to the

fact that Von Ihering did not measure in the way I did (See p. 526). If I measure the length of my specimens along the longest axis (diagonally), and the height vertically to it, I obtain for the above specimens figures more nearly agreeing with those of Von Ihering from 51 to 59 pr. ct. of length.

MEASUREMENTS.

| Localities. | No. | Sex. | Length. | Height. | Diameter. | Beaks. | Figured. |
|---|---|---|---|---|---|---|---|
| Santa Isabel. | 3 | ? | 95 mm. | 59.5mm. =63 pr.ct. of L. | 32 mm. =34 pr. ct. of L. | at 28 mm. =29 pr. ct. of L. | |
| Do. | 4 | ? | 102 " | 55 " =54 " | 38 " =37 " | 29.5 " =29 " | |
| Do. | *a* | ♂ | 107 " | 63 " =59 " | 43 " =40 " | 36 " =30 " | |
| San Isidro... | *y* | ♀ | 123 " | 74 " =60 " | 48 " =39 " | 36 " =29 " | Pl. XLIII, f. 2. |
| Do. ... | *x* | ♂ | 123.5 " | 76.5 " =61 " | 49 " =40 " | 36 " =29 " | Pl. XLIII, f. 3. |
| Do. ... | *z* | ♀ | 136 " | 86 " =63 " | 54 " =40 " | 45 " =33 " | Pl. XLIV, f. 2. |

In other respects, the characters given by Von Ihering for *riograndensis* agree with my specimens. This is especially true of the diameter, which, according to Von Ihering ranges from 30 to 39 pr. ct., and in my specimens from 34 to 40 pr. ct. Von Ihering believes that the diameter as well as the height differ according to sex. According to my material there surely is no such differentiation. It is impossible to directly compare my measurements for the location of the beaks (29 to 33 pr. ct.) with those given by Von Ihering, because he measured the distance from the anterior end of the hinge-line (34 to 43 pr. ct.); but I should say that measurements of my specimens taken in the same way give, for the above specimens, the values: 36, 35, 37, 43, 40, 44 pr. ct. of length, agreeing fully with Von Ihering's.

The point of the beaks is inclined forwards, as Von Ihering mentions, but not too much stress should be laid upon this character. An important feature, however, is the curved hinge-line.

*Glabaris trapesialis cygneiformis* Pilsbry (1896, p. 563, Pl. 26, figs. 4, 5) from Maldonado, Uruguay, surely is closely allied. But, as Pilsbry points out, it is more compressed than *riograndensis* (Diam. only 26 pr. ct.), and its posterior end is more elevated above the base-line; it is thus less oblique. For this reason I cannot unite it with the present species, although it may fall under it.

*Glabaris simpsonianus* Pilsbry (ibid., p. 564, Pl. 27, fig. 13) from Rio de la Plata, is also very much like *riograndensis*. The height of 56 pr. ct. and the diameter of 38 pr. ct. fall within the range of variation of *riograndensis*. But it is said to be a very solid shell, of a rather regular, oblong-oval shape, with a large, elongated anterior protractor scar. Having no specimens corresponding to it, I cannot express an opinion.

*Anatomy*.—The soft parts of three males and two gravid females are at hand,

the latter collected in January. Von Ihering found gravid females with lasidia on May 28.

Anal opening entirely open, its inner edge smooth, separated from the branchial opening by a mantle-connection. Branchial opening with fine papillæ on inner edge. Palpi very large, nearly semicircular, lower margins rounded, posteriorly truncated, without a posterior point. Posterior margins widely separated at base (this is a peculiar feature, not observed in any of the foregoing species).

Gills long and wide, the inner the wider anteriorly, its anterior end inserted between the posterior ends of the palpi (this is also a peculiar feature). Outer gill with the anterior end at the highest point of the mantle-attachment-line. Inner lamina of inner gill entirely connected with abdominal sac. Gills with well developed septa running in the direction of the gill-filaments, alternately (but irregularly so) stronger and weaker in the non-marsupial gills. The inner gill of the female is *marsupial,* with stronger, more uniform septa, which, however, are not more closely set, and have the usual vertical ridges near the outer lamina, projecting into the lumen of the water-tubes. When charged, only the inner compartment is filled with ova, thus becoming an ovisac, while the outer compartment remains a (secondary) water-tube. Egg-masses only loosely hanging together. Eggs very small, according to Von Ihering 0.071 to 0.090 mm. in diameter, while I have found them to be about 0.08 mm. In this species also I have not been able to find mature larvæ, but this is one of the species, in which Von Ihering has observed the *lasidium,* which he describes as being 0.1 mm. long.

### 63. Anodontites forbesiana (Lea) (1860).

*Shells:* Plate XLIII, fig. 4; Plate XLIV, fig. 3.

Simpson, 1914, p. 1438.

*Additional References.—Anodonta forbesiana* Von Ihering, 1890, p. 158. Corsi, 1901, p. 457.

*Glabaris forbesianus* Pilsbry & Rush, 1896, p. 81.

*Type-locality.*—Uruguay River.

*Other Localities.*—Rio de la Plata, Colonia, Uruguay (Pilsbry & Rush).

*New Localities.*—Rio Uruguay (in mud), Uruguayana, Rio Grande do Sul, Brazil (J. D. Haseman coll., February 5, 1909). Fourteen specimens, males and females, all with soft parts. In pond along banks of Rio Negro, Santa Isabel, Uruguay (J. D. Haseman coll., February 11, 1909). Two odd right valves.

*Distribution.*—Known only from the Rio de la Plata below the mouth of the Uruguay, Rio Uruguay up to Rio Grande do Sul, and its tributary the Rio Negro.

Simpson also gives Peru, but I do not know on what authority, and strongly doubt this record.

Von Ihering (1890) pointed out the differences from *A. riograndensis*, to which this species is closely allied. The original specimens of *A. forbesiana* were injured at the posterior end, and it was believed that in uninjured ones this end might be more strongly produced. However, Lea's figure shows in the growth-lines that the shape of the shell, before it was injured, was similarly truncated, and my series, which contains a majority of intact shells, demonstrates that the normal shape of this species also exhibits this truncation, *i.e.*, a steeply descending posterior margin. This is the chief character of this species, and in consequence, the dimensions are different from those of *A. riograndensis*.

This difference is seen first of all in the height, which varies from about 60 to 69 pr. ct., falling under 60 pr. ct. only in very young specimens, while in *riograndensis* it is from 54 to 63 pr. ct. The diameter of the two species is about the same, but slightly higher on the average in *forbesiana* (35 to 48 pr. ct. and in young ones as low as 33 pr. ct. against 34 to 40 in *riograndensis*). The beaks of *forbesiana* are farther removed from the anterior end: 32 to 38 pr. ct., against 29 to 33 pr. ct. in *riograndensis*. Von Ihering gives the umbonal index as 48 pr. ct., but this is due to his different method of measuring; measured in my specimens according to his method, it would be from 42 to 56 pr. ct., while it is 34 to 43 pr. ct. in *riograndensis*. The index above 50 pr. ct. is found only in my youngest specimens, where the ligamental sinus is very anterior, thus making the hinge-line very short.

Finally, in *forbesiana*, the hinge-line is practically straight, as mentioned by Von Ihering, and represented in Lea's figure. This holds good in all of my specimens.

In other respects this species agrees with *riograndensis*, but it should be remarked that the radial scalariform stripes are generally absent or very poorly developed; only in one or two cases a few of them are distinctly seen on the anterior part of the shell.

MEASUREMENTS (SPECIMENS FROM URUGUAYANA).

| No. | Sex. | Length. | Height. | Diameter. | Beaks. | Figured. |
|---|---|---|---|---|---|---|
| *c*... | ♂(?) | 29 mm. | 16 mm. =55 pr.ct. of L. | 9.5mm. =33 pr.ct. of L. | at 10 mm. =34 pr. ct. of L. | |
| 1... | ♂ | 49 " | 29 " =59 " | 17.5 " =36 " | 17 " =35 " | |
| 2... | ♂ | 71 " | 42.5 " =60 " | 25 " =35 " | 23 " =32 " | |
| 4... | ♀ | 72 " | 47 " =65 " | 28 " =39 " | 25.5 " =35 " | |
| 7... | ♀ | 85 " | 51.5 " =64 " | 36 " =42 " | 29 " =34 " | |
| 8... | ♂ | 87 " | 59 " =68 " | 42 " =48 " | 33 " =38 " | Pl. XLIII, fig. 4. |
| 10... | ♂ | 100 " | 69 " =69 " | 43 " =43 " | 37 " =37 " | |
| 11... | ♀ | 108 " | 70 " =65 " | 46 " =43 " | 38.5 " =36 " | Pl. XLIV, fig. 3. |
| Lea's fig... | | 114 " | 71 " =62 " | 54 " =47 " | 44 " =38 " | |

Simpson's measurements do not agree with these figures.

It should be noticed that young specimens are not so high, and also less swollen than older individuals, and thus the typical shape is less evident in them. They are also extremely thin-shelled, while older ones are rather solid.

*Anatomy.*—I have nine males and five females. The structure is exactly like that of *A. riograndensis.* The palpi have their posterior bases separated; for about two-thirds of their length the bases are contiguous, but then they diverge. The inner gill begins just without and close to the end of the inner palpus.

### 64. Anodontites rioplatensis (Sowerby) (1870).

*Anodon rioplatensis* Sowerby, XVII, 1870, Pl. 26, fig. 101.
*Glabaris trapesialis rioplatensis* Simpson, 1900, p. 925.
*Anodontites trapesialis rioplatensis* Simpson, 1914, p. 1431.

*Type-locality.*—Rio de la Plata.

*Other Localities.*—Haas (1916, pp. 29, 54) mentions a closely related form from Rio Uruguay, Salto Oriental, Uruguay, which may, or may not, be this.

*New Locality.*—Rio Limay, Patagonia, Argentina (received in exchange from W. Israël). One specimen.

*Distribution.*—The Rio de la Plata and Rio Negro drainages in Argentina. Possibly also in Rio Uruguay.

We may regard this as an exaggerated *forbesiana*, with the shell higher and shorter, and the beaks more central, but in all other respects it is similar. Sowerby calls the shell thin, and describes concentric "wrinkles" on the beaks. Our specimen is rather solid, and the wrinkles are nothing but growth-lines.

Measurements.

| Length. | Height. | Diameter. | Beaks. | |
|---|---|---|---|---|
| 108 mm. | 82 mm. = 76 pr. ct. of L. | 49.5 mm. = 46 pr. ct. of L. | at 43 mm. = 40 pr. ct. of L. | (my specimen) |
| 106 " | 76 " = 72 " | | | (Sowerby's figure) |

### Subgenus Lamproscapha Swainson (1840).

*Lamproscapha* Swainson, Treat. on Malacology, 1840, p. 381.
*Virgula* Simpson, 1900, p. 931; 1914, p. 1454.

Shell greatly elongated, knife-shaped, sharply pointed behind, with a sharp posterior ridge. Posterior retractor-scar completely separated from the adductor-scar, and remote from it by about one to three times its own diameter. Epidermis not shining, covered with very fine concentric (posteriorly) and radial scalariform (anteriorly) wrinkles.

The greatly elongated shape and the posterior retractor-scar are evidently correlated characters. This subgenus apparently stands close to the *crispata*-group of *Anodontites* in the sculpture of the epidermis.

Swainson introduced *Lamproscapha* for four species, of which the first (*elongata* Swainson) was doubtfully referred here. The second is *ensiformis*. If the latter is to be separated from *Anodontites*, *Lamproscapha* is the oldest available name.

65. Anodontites (Lamproscapha) ensiformis (Spix) (1827).

*Anodon ensiformis* Spix & Wagner, 1827, p. 31, Pl. 24, figs. 1, 2. Sowerby, XVII, 1867, Pl. 11, fig. 31 (young).

*Anodonta ensiformis* D'Orbigny, 1843, p. 618, Pl. 79, fig. 10. Von Ihering, 1890, p. 161.

*Glabaris ensiformis* Simpson, 1900, p. 932.

*Anodontites ensiformis* Simpson, 1914, p. 1455. Haas, 1916, pp. 36, 57.

*Type-locality* not given.

*Other Localities.*—Rio San Miguel (= Rio Itonama), Bolivia (tributary to Guaporé) (D'Orbigny); Rio Piray, Santa Cruz de la Sierra, Bolivia (tributary to Rio Marmoré, into which the Guaporé flows) (D'Orbigny); Rio Napo, Mazan, Peru (Haas). Repeatedly reported from Brazil, but no exact localities given.

Lea (Obs. XIII, 1874, p. 27) mentions this species as having been found in Guyana, in connection with a species from Yuruari River (tributary to Essequibo). Simpson (1900, p. 932 and 1914, p. 1456) describes a new species (*A. falsa*) taken by Lea for *ensiformis*, from the same river (Yuruari), "a branch of the Orinoco." The Yuruari, however, is a tributary of the Essequibo, but is located chiefly in Venezuela, not in Guyana, and does not belong to the Orinoco-system.

*New Locality.*—Rio Machupo, San Joaquim, Bolivia (tributary to Rio Itonama and Guaporé) (J. D. Haseman coll., September 5, 1909). Four specimens, three of them with soft parts. Another specimen is in the Carnegie Museum (from the Hartman collection) labeled "Brazil."

*Distribution.*—Definite localities are so far known only from the upper Amazon and Madeira drainages in Peru and Bolivia.

*Characters of the Shell.*—Shell moderately thick; outline much elongated, knife-like, pointed behind. Height 25 to 33 pr. ct. of the length. Valves not gaping. Dorsal and ventral margins practically parallel, except towards the posterior end, where the dorsal margin curves in a gentle curve or a very obtuse angle into the posterior margin, which descends obliquely and is straight or gently concave. At the posterior end the margin curves sharply around to the ventral

margin, forming a blunt, but distinct point, which is hardly, or very little, elevated above the base-line. Lower margin almost straight, but with a more or less distinct concavity in the middle. Anteriorly the lower margin curves up into the rounded anterior margin.

Valves very slightly convex, practically flat upon the sides, and, in large specimens, even with a shallow depression corresponding to the concavity of the lower margin. The posterior ridge is distinct, but rounded, running towards the posterior point of the shell. Above this ridge, the shell is somewhat compressed. Diameter 14 to 20 pr. ct. of the length. Beaks low, and hardly elevated above the hinge-line, located at 18 to 26 pr. ct. of the length, and proportionally more anterior in older specimens; the large specimen, described by D'Orbigny, has them at 15 pr. ct. of the length.

Epidermis not smooth, with irregular concentric lines, heaviest upon the posterior ridge, and with very fine striæ, sublamelliform upon the posterior slope and towards the margins. Faint radiating lines are present, dividing the fine striæ into scalariform stripes of crowded, fine wrinkles, visible only in well-preserved specimens, and restricted to the anterior part of the shell. Color of epidermis greenish or brownish olive, inclining to blackish in old shells, without color-markings and without distinct growth-rests.

Hinge-line straight behind the beaks, slightly descending in front of them. Ligamental sinus much wider than deep, its anterior margin oblique to the hinge-line, but more nearly vertical in the largest specimen at hand.

Cavity of shell and beaks very shallow. Nacre, in all of my specimens, whitish, but with bluish and purplish iridescence (according to other authors, it is sometimes coppery), with irregular radiating lines, most distinct towards the margins. Prismatic zone rather narrow, and subconcentric with the margin. Anterior adductor-scar well impressed, subovate. Anterior retractor-scar distinct, but connected with that of the adductor-scar. Anterior protractor-scar separated. Posterior adductor-scar faint, subovate. Posterior retractor-scar separated from the latter and rather removed from it, at least by as much as its own width; in old shells up to three times its width.

*Remarks.*—There can be no mistaking this species, the elongated shape being so characteristic, that no other South American form could be taken for it, with the possible exception of *A. falsa* (Simpson) from Venezuela (See above). It constitutes with the latter a peculiar group within the genus, but approaches the normal *Anodontites* (of the *crispata*-type) more than any other. The location

of the posterior retractor-scar is quite unique, but, of course, is connected with the elongated shape of the shell.

MEASUREMENTS.

| Locality. | No. | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|---|
| S. Joaquim.......... | | 35 mm. | 10 mm. =29 pr. ct. of L. | 6 mm. =17 pr. ct. of L. | at 9 mm. =26 pr. ct. of L. |
| Do. .......... | 1 | 50 " | 15 " =30 " | 10 " =20 " | 10 " =20 " |
| Do. .......... | 2 | 55 " | 14 " =25 " | 9 " =16 " | 11 " =20 " |
| Do. .......... | 3 | 52 " | 17 " =33 " | 10 " =19 " | 10 " =19 " |
| "Brazil"............ | | 78 " | 20 " =26 " | 12 " =15 " | 14 " =18 " |
| D'Orbigny.......... | | 130 " | =29 " | =19 " | =15 " |
| Simpson............ | | 97 " | 25 " =26 " | 15 " =15 " | |
| Do. ............ | | 106 " | 27 " =25 " | 15 " =14 " | |

*Anatomy.*—The soft parts of three specimens are at hand, but their sex is not positively known.

The structure is that of the genus *Anodontites*, with such modifications as are caused by the elongation of the shell. The mantle-connection between anal and branchial openings is a little longer than usual, the gills are extremely long and narrow, and the part behind the foot, where the two inner laminæ of the inner gills are connected, is proportionally longer than in any other species. As indicated by the scars of the shell, the posterior retractor muscle is considerably removed from the adductor.

Anal opening entirely open. Branchial opening with very small papillæ. Palpi comparatively long, but narrow, lower margins forming a gentle curve. Posteriorly they are very briefly truncated, forming the posterior margins, which are not connected. Structure of gills as usual, with distinct septa. I have not been able to positively identify the sex of the three specimens at hand: the condition of the gills is rather unsatisfactory, they being much torn, so that no sections could be made, and from macroscopical examination (and with a lens) no indications of a differention of the inner gills could be detected: this, indeed, would indicate the male sex, but my specimens are too young for one to be sure about this. The inner gill, as usual begins immediately behind the palpi, and the inner lamina of the inner gill is entirely connected with the abdominal sac. Foot rather long, but altogether small; of course, the real shape could not be made out on account of the contraction in alcohol.

## Genus MYCETOPODA D'Orbigny (1835).

Simpson, 1914, p. 1457.

Characterized by very elongated, subtrapezoidal shell, which is widely gaping in front. The chief characters, however, are in the soft parts. The foot is ex-

tremely elongated and dilated at the end (button-like), and probably is in life never entirely withdrawn into the shell (hence the gaping margins). In addition, the branchial opening is said to be closed below (Simpson), but I have not been able to confirm this, and furthermore the pallial line does not show any indication of this (having no sinus). D'Orbigny makes the positive statement that the branchial is not closed. The anal opening is closed in part.

This genus has a wide distribution in South America, from the Cordilleras eastward, and from Argentina northwards into Central America, at least as far as Guatemala.

Von Ihering has given a key for the species (1910, p. 118); although this is not always quite satisfactory, I have used it in the identification of my comparatively meagre material. Von Ihering's treatment of the genus surely has cleared up a good deal, but it is not to be regarded as final. His opinion that there are species of this genus in Eastern Asia (*Solenaia*) certainly is incorrect. We do not know the anatomical structure of the latter, except that the foot is said to be similarly developed. But we must not forget, that there is a North American *Unionid*-shell (*Lastena lata*), which also has a foot like this. In the muscle-scars, the ligamental sinus, and the beak-sculpture *Solenaia* undoubtedly differs from the South American *Mycetopoda*, which according to the anatomy is a *Muteline*-shell.

The species (*subsinuata*) of which I have studied the anatomy, has another character, the partly closed anal-opening, in which it differs from all South American *Mutelinæ*, and resembles the African members of this subfamily. This may be another peculiar feature of the genus, but it is desirable that other species should be examined as to this.

### 66. Mycetopoda siliquosa (Spix) (1827).

*Mycetopoda siliquosa* Von Ihering, 1910, p. 120; Simpson, 1914, p. 1458.
*Mycetopoda bahia* Von Ihering, 1910, p. 122, Pl. 12, fig. 3; Simpson, 1914, p. 1463.

According to Simpson, *M. legumen* (Von Martens) and *M. clessini* Von Ihering belong here.

*Type-locality.*—Rio Paraguassú, Bahia, Brazil.

*Other Localities.*—Rio Piracicaba, Piracicaba, São Paulo, Brazil (Von Ihering, 1893); Rio São Francisco, Villa Nova, Sergipe (not Bahia), Brazil (Von Ihering, *M. bahia*).

*New Locality.*—Lagoa Salgado, Bahia, Brazil (upper Rio Salitré, tributary to São Francisco) (J. D. Haseman coll., November 10, 1907). Two specimens. Two

other specimens are in the Carnegie Museum, without exact localities, from the Holland and Juny collection respectively.

*Distribution.*—Restricted to eastern Brazil, to the drainages of the Rio Paraná in São Paulo, and of the Rio Paraguassú and Rio São Francisco in Bahia and Sergipe. Possibly more widely distributed in the São Francisco system.

Haas (1916, p. 37, 58) gives this species also from Rio Unuyacu (tributary to Rio Napo) in Ecuador; however, he conceived it in Simpson's sense, and we cannot be sure that it is *M. siliquosa* as defined by Von Ihering.

My specimens fully agree with the account given by Von Ihering, and their measurements come very close to those given by him.

MEASUREMENTS.

| Locality. | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|
| Lagoa Salgado | 72 mm. | 26 mm. =36 pr. ct. of L. | 13.5 mm. =17 pr. ct. of L. | at 19 mm. =26 pr. ct. of L. |
| Holland coll. | 80 " | 29.5 " =37 " | 15 " =19 " | 20 " =25 " |
| Juny coll. | 85.5 " | 31 " =36 " | 15 " =18 " | 21 " =25 " |
| Lagoa Salgado | 89 " | 35 " =39 " | 20 " =22 " | 27 " =30 " |
| Spix' type | 80 " | 31 " =39 " | | 22 " =28 " |

The figures for Spix' type are taken from Von Ihering (1890). Von Ihering (1910, in the key) gives the location of the beaks as ranging from 18 to 29 pr. ct. and the height as ranging from 35 to 37 pr. ct. of the length.

*Remarks.*—In all of my specimens, the posterior adductor scar is presinual. *M. bahia* is founded upon a single specimen, which has the measurements: L. 78, H. 27 = 35 pr. ct., D. 15.5 = 20 pr. ct., beaks at 23 = 30 pr. ct. These figures fall within the range of variation of *M. siliquosa*. In Von Ihering's key there is here a weak point, since the forms are distinguished chiefly by the location of the beaks, with the figures partly overlapping. I cannot find any difference in *bahia* from *siliquosa*, except that the lower margin in the former ascends slightly behind, and that the posterior adductor scar is said to be "subsinual, in part even a little presinual." The first character very well may be individual; the second, disregarding the fact that it is hard to understand, does not at all differ from *siliquosa*, where this scar is simply presinual. Indeed, my young specimen from Lagoa Salgado has the adductor-scar less in advance of the ligamental sinus than the larger. Altogether, this young specimen is extremely close to *bahia*, only the posterior lower margin is not curved up, and the beaks are more anterior. It is also remarkable for the great thinness and transparency of the shell. Therefore I think that *M. bahia* is only a young individual of *M. siliquosa*.

67. Mycetopoda staudingeri (Von Ihering) (1890).

*Mycetopus staudingeri* Von Ihering, 1890, p. 130, figs. A, B.
*Mycetopoda staudingeri* Simpson, 1900, p. 934; Von Ihering, 1910, p. 121.
*Mycetopoda siliquosa staudingeri* Simpson, 1914, p. 1460.

*Type-locality.*—Rio Huayabamba, Peru (tributary to Rio Huallaga).

*Additional Locality.*—Rio Huallaga, Peru (Von Ihering).

*Locality Represented in Carnegie Museum.*—Marañon, Upper Amazon (Hartman collection). One specimen.

*Distribution.*—Headwaters of the Amazon in Peru; a variety (*æquatorialis* Von Ihering) in Ecuador.

Our specimen agrees very well with Von Ihering's description and figures, chiefly with fig. *A* (which is supposed to be a male) but it to a certain degree stands between figs. *A* and *B* (See measurements of height). The postsinual position of the posterior adductor-scar is evident and remarkable, and it seems, indeed, that this is an important taxonomic character. The posterior end of the upper margin (behind the ligamental sinus) is in my specimen not so greatly elevated as in Von Ihering's figures.

Measurements.

| | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|
| My specimen | 94 mm. | 38 mm. =40 pr. ct. of L. | 19 mm. =20 pr. ct. of L. | at 24 mm. =25 pr. ct. of L. |
| Von Ihering, *A* | 93 " | 35 " =38 " | | |
| Do. , *B* | 103 " | 43 " =42 " | 21 " =20 " | |

In 1910, Von Ihering gives for the height 35 to 37 pr. ct. of the length, which does not exactly agree with his original figures. The location of the beaks is according to him is 27 to 28 pr. ct. of the length.

68. Mycetopoda subsinuata (Sowerby) (1868).

*Mycetopus subsinuatus* Sowerby, XVI, 1868, Pl. 4, fig. 10; Von Martens, 1900, p. 540, Pl. 41, fig. 5.
*Mycetopoda subsinuata* Simpson, 1900, p. 934; Von Ihering, 1910, p. 120; Simpson, 1914, p. 1461.

*Type-locality.*—Bogota, Colombia.

*Other Localities.*—Ecuador (Von Ihering); Paso Antonio, West Guatemala (Pacific slope) (Von Martens).

*New Localities.*—Marañon, Upper Amazon (Peru) (Hartman coll.). Three complete specimens, four left valves. Rio Conchins, Maya Farm, Quirigua, Guatemala (Atlantic slope, to Rio Montagua) (A. A. Hinkley coll., February 6,

1913). One shell, female, with soft parts, and soft parts of a male and female without shells.

*Distribution.*—From the upper Amazon drainage in Peru and Ecuador through Colombia into Central America, northward to Guatemala, where it is found both on the Atlantic and Pacific slopes.

Von Ihering's key has failed me in the identification of this species, since he uses size as a criterion, while my specimens are all rather small. The height, also used as a distinctive character, is apparently unreliable, as shown by my specimens. Therefore this group (*hh* in the key) needs revision.

Nevertheless the two largest specimens at hand (one from the upper Amazon, the other from Guatemala) agree fairly well with Von Ihering's account and measurements, and also with those of Von Martens. There is no question about the identity of the Central American specimens with the form from northern South America. The posterior adductor-scar is said to be subsinual (Von Ihering p. 118). This fits my smaller specimens from the upper Amazon, while the larger one is peculiar. It appears as if there were in each valve two superimposed scars, the one more anterior, the other a little farther back. The latter is superficial, but apparently corresponds to the latest growth-addition to the shell. Its anterior end is slightly in advance of the ligamental sinus (presinual). In this specimen, however, there is a disturbance of the regular growth, as indicated by a strong growth-rest on the outside of the shell, and the shell looks as if stunted behind. This individual is therefore not normal. In the large specimen from Guatemala, the scar is also slightly presinual (about one-third of the retractor-process projecting in front of the sinus), and in Von Martens' figure (representing a very large specimen) this scar is still more presinual.

The sinuosity of the lower margin is seen in my two larger specimens, but is not so strong as in Sowerby's and Von Martens' figures. The young specimens, which undoubtedly belong with the larger one, show hardly a trace of this sinuosity.

MEASUREMENTS.

| Locality. | No. | Sex. | Length. | Height. | Diameter. | Beaks. |
|---|---|---|---|---|---|---|
| Marañon | 1 | ? | 58 mm. | 17 mm. =29 pr. ct. of L. | 10 mm. =17 pr. ct. of L. | at 15 mm. =26 pr. ct. of L. |
| Do. | 2 | ? | 63 " | 19 " =30 " | 10 " =16 " | 17 " =27 " |
| Do. | 3 | ? | 75 " | 23 " =31 " | 12 " =16 " | 20 " =27 " |
| Do. | 4 | ? | 75 " | 23 " =31 " | 12 " =16 " | 20 " =27 " |
| Guatemala | | ♀ | 86 " | 28 " =33 " | 17.5 " =20 " | 21.5 " =25 " |
| Marañon | 5 | ? | (88) " | 31 " =(35 " ) | 20 " =(23 " ) | 26 " =(30 " ) |
| Sowerby | | | 118 " | 41 " =35 " | | |
| Von Martens | | | 125 " | 43 " =34 " | 23 " =18 " | |
| Do. | | | 132 " | 45 " =34 " | 23 " =17 " | 29 " =32 " |

My specimen, No. 5, from the Marañon is the one, which probably is injured, and the length probably would be greater, when normal; this, of course, has influence on the other indices, which are all somewhat too high. The figures taken from Sowerby and Von Martens are close to mine. The greater height undoubtedly is due to the larger size of the specimens, and probably also to the more anterior location of the beaks.

*Anatomy.*—Soft parts of one male and two females at hand, one of the latter is gravid (collected February 6).

The anatomy is that of the South American *Mutelinæ*, but it resembles that of the African *Mutelinæ*, in having the anal opening closed above for about half of its length. The opening is therefore comparatively short, being only a little longer than the branchial opening, and reaching upward only to about the middle of the adductor muscles. In other South American *Mutelinæ* it reaches upward beyond the posterior retractor-muscles. The anal is separated from the branchial opening by a connection of the mantle; its inner edge is smooth. Branchial opening with fine papillæ on the inner edge. Although Simpson says that the branchial opening is closed below, I cannot find any trace of a mantle-connection at the lower (anterior) end. There is also no indication that such a connection has been torn during life, or in preservation. Palpi long and low, their lower margins curved, not drawn out into a posterior point, posteriorly with a short truncation, forming the posterior margins, which are not connected.

Foot very large, subcylindrical and subcompressed, at the distal end swollen into a button-like knob. This structure is likewise not seen in other *Muteline* shells.

Gills long and narrow, the inner the wider, the anterior ends as usual. Inner lamina of inner gill entirely connected with abdominal sac. Distinct, continuous septa of the *Muteline* type are present. The inner gill of the female is *marsupial*, with thicker, but not more crowded, septa; the water-tubes are again divided by vertical ridges into an inner and outer compartment, the inner of which serves as ovisac, the outer as secondary water-canal. Eggs small, loosely hanging together. I have not been able to find mature larvæ in my gravid female.

### Genus Leila Gray (1840).

Simpson, 1914, p. 1399.

The chief character of this genus is the sinus of the pallial line below the posterior adductor-scar, which is said to be connected with the closing of the branchial opening at its lower (anterior) end, but particulars about this are not known.

In other respects the shell of this genus is very similar to that of the species

of the *trapesialis*-group of *Anodontites*, with which it also has in common the gaping margins. A peculiar character, generally missing in South American *Mutelinæ*, is the presence of an oblique row of dorsal muscle-scars in the beak-cavity.

There can be hardly any question that this genus represents a more highly specialized type of the genus *Anodontites*, and that its root is in the *trapesialis*-group. Its distribution extends over South America, east of the Andes, and from the basin of the Amazon southward to northern Argentina.

The genus *Leila* is in great confusion, although there seem to exist only a few species. Its revision has been attempted by Von Ihering (1890, p. 39) and by Simpson, (1900, p. 914), but these two authors have arrived at very different conclusions. Both agree in recognizing two groups: the one containing species with a practically straight hinge-line (*L. blainvilleana* and *L. spixi*), the other species with a curved or sinuate hinge-line. While Simpson unites all of the forms belonging to the latter group, into one species (*L. esula*), Von Ihering distinguishes three as valid.

My material is entirely insufficient to permit me to decide this point. The specimens before me unquestionaly come under *L. castelnaudi* Hupé, and so I shall record them under this name, without attempting to pass upon the question whether then are different from *esula* D'Orbigny and from *pulvinata* Hupé. They also agree fairly well with Von Ihering's description of *castelnaudi*.

### 69. Leila castelnaudi Hupé (1857).

*Leila castelnaudi* Hupé, 1857, p. 91, Pl. 19, fig. 1.
*Anodon castelnaudi* Sowerby, XVII, 1868, Pl. 20, fig. 79.
*Columba castelnaudi* Von Ihering, 1890, pp. 139, 142.

According to Simpson (1914, p. 1401) this is identical with *L. esula* (D'Orbigny).

*Type-locality.*—"Bourbon ou Olympo, Paraguay." This probably is Fuerte Olympo, on Rio Paraguay, northern Paraguay.

*New Localities.*—Rio Paraguay, Corumbá, Matto Grosso, Brazil (H. H. Smith coll.). One left valve. Swamp of Lambaré, Asunción, Paraguay (J. D. Haseman coll., March 31, 1909). One left valve.

Measurements.

| Locality. | Length. | Height. | Diameter. | Beaks. | Hinge-line. |
|---|---|---|---|---|---|
| V. Ihering | 138 mm. | 96 mm. =70 pr.ct. of L. | | | 105 mm. =76 pr.ct. of L. |
| Asunción . | 158 " | 112 " =71 " | 88 mm. =43 pr. ct. of L. | at 48 mm. =30 pr. ct. of L. | 101 " =64 " |
| Corumbá . | 166 " | 116 " =70 " | 70 " =42 " | 52 " =31 " | 114 " =69 " |

Von Ihering has measured according to a peculiar method, but I see no par-

ticular advantage in this. Yet the length of the hinge-line from its anterior end to the anterior end of the ligamental sinus, and its proportion to the length of the shell, should be noted, because there are slight differences in our specimens in this respect.

According to Hupé's figure, the beaks are located at 44 mm. = 32 pr. ct. of length. This and the height given by Von Ihering agree very well with my specimens, but the proportion of the hinge-line to the total length is less in the latter. But the figures for my specimens show that that there is variation in this respect.

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(*Note:* As to the authorship of the species described by Spix and Wagner, *Cf.* Von Ihering, 1890, pp. 118–119, footnote).

## EXPLANATION OF PLATE XXXIV.

SHELLS OF DIPLODON HASEMANI ORTMANN AND DIPLODON IMITATOR ORTMANN.

All figures natural size.

FIGS. 1–4. *Diplodon hasemani* Ortmann, from Rio Guaporé, near Rio São Simão, Matto Grosso, Brazil. Carn. Mus. Cat. No. 61.5857.

FIG. 1*a*. Adult male (No. 10), lateral view.

FIG. 1*b*. Adult male (No. 10), dorsal view.

FIG. 2*a*. Adult, gravid female (No. 9), lateral view.

FIG. 2*b*. Adult, gravid female (No. 9), inner view of left valve.

FIG. 2*c*. Adult, gravid female (No. 9), inner view of right valve.

FIG. 3. Half-grown, gravid female (No. 4), lateral view.

FIG 4. Young, gravid female (No. x), lateral view.

FIGS. 5–7. *Diplodon imitator* Ortmann, from Rio Vaccahy-mirim, Santa Maria, Rio Grande do Sul, Brazil. Carn. Mus. Cat. No. 61.9248. (See also Pl. XXXV, figs. 1 and 2).

FIG. 5*a*. Half-grown male (No. 29), lateral view.

FIG. 5*b*. Half-grown male (No. 29), inner view of left valve.

FIG. 5*c*. Half-grown male (No. 29), inner view of right valve.

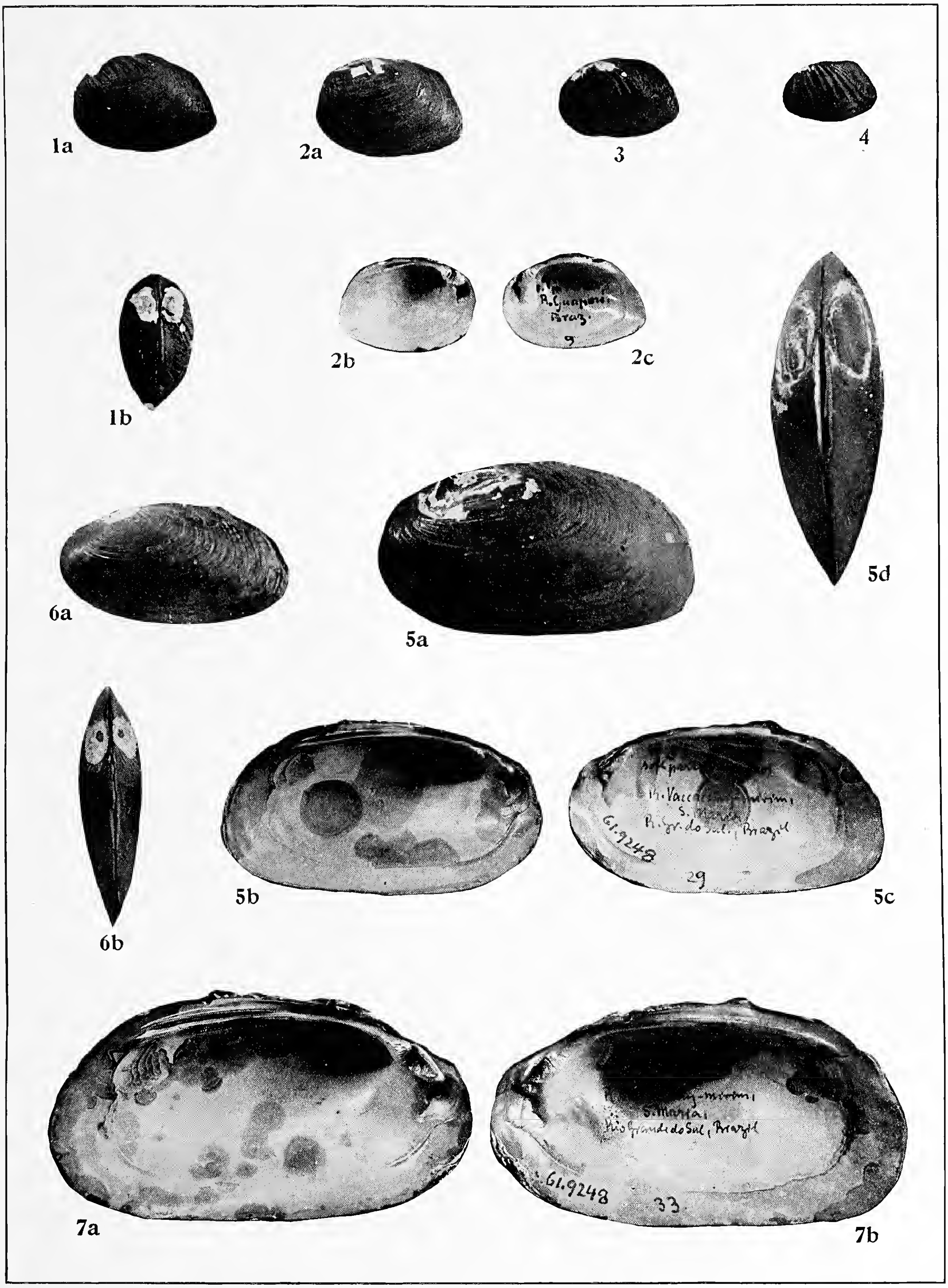
FIG. 5*d*. Half-grown male (No. 29), dorsal view.

FIG. 6*a*. Young male (No. 14), lateral view.

FIG. 6*b*. Young male (No. 14), dorsal view.

FIG. 7*a*. Adult female (No. 33), inner view of left valve (see also Pl. XXXV, fig. 1).

FIG. 7*b*. Adult female (No. 33), inner view of right valve.




DIPLODON.

## EXPLANATION OF PLATE XXXV.

Shells of Diplodon imitator Ortmann, Diplodon simillimus Ortmann, and Diplodon vicarius Ortmann.

All figures natural size.

Figs. 1 and 2. *Diplodon imitator* Ortmann, from Rio Vaccahy-mirim, Santa Maria, Rio Grande do Sul, Brazil. Carn. Mus. Cat. No. 61.9248 (See also Pl. XXXIV, figs. 5–7).

Fig. 1. Adult female (No. 33), lateral view (same specimen as that figured on Pl. XXXIV, fig. 7).

Fig. 2. Young, gravid female (No. 21), lateral view.

Figs. 3–6. *Diplodon simillimus* Ortmann, from Rio Nhundiaquara, Morretes, Paraná, Brazil. Carn. Mus. Cat. No. 61.9250.

Fig. 3. Half-grown male (No. 11), lateral view.

Fig. 4. Half-grown male (No. 16), lateral view.

Fig. 5*a*. Adult, gravid female (No. 22), lateral view.

Fig. 5*b*. Adult, gravid female (No. 22), dorsal view.

Fig. 5*c*. Adult, gravid female (No. 22), inner view of left valve.

Fig. 5*d*. Adult, gravid female (No. 22), inner view of right valve.

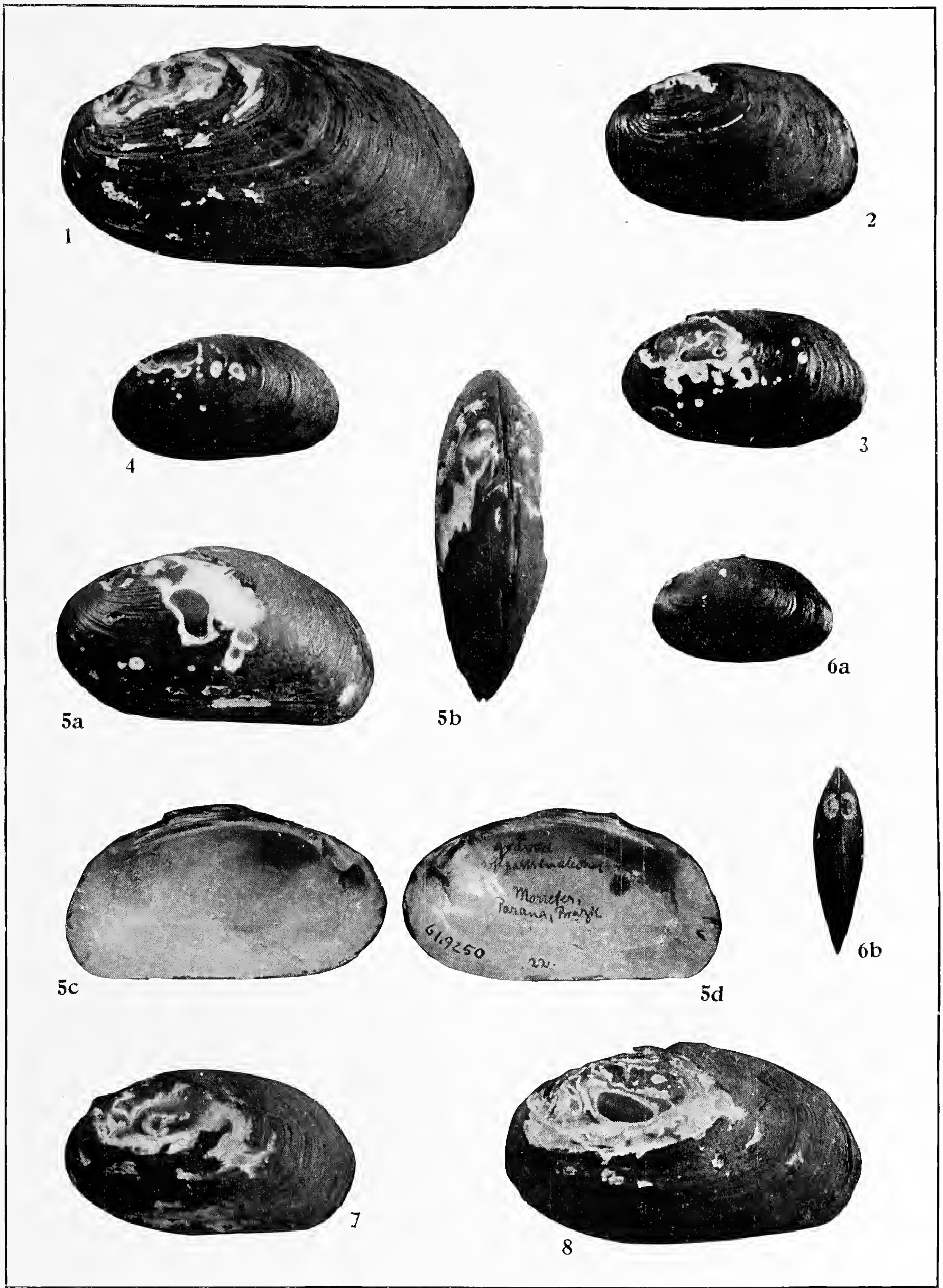
Fig. 6*a*. Young, gravid female (No. 24), lateral view.

Fig. 6*b*. Young, gravid female (No. 24), dorsal view.

Figs. 7 and 8. *Diplodon vicarius* Ortmann, from creek (Rio Ribeira drainage), Aqua Quente, near Iporanga, São Paulo, Brazil. Carn. Mus. Cat. No. 61.9251 (See also Pl. XXXVI, figs. 1 and 2).

Fig. 7. Half-grown male (No. 13), lateral view.

Fig. 8. Adult female (No. 15), lateral view (See also Pl. XXXVI, fig. 1).




DIPLODON.

# EXPLANATION OF PLATE XXXVI.

## SHELLS OF DIPLODON VICARIUS ORTMANN, DIPLODON DECIPIENS ORTMANN, AND DIPLODON HILDÆ ORTMANN.

All figures natural size.

FIGS. 1 AND 2. *Diplodon vicarius* Ortmann, from creek (Rio Ribeira drainage), Aqua Quente, near Iporanga, São Paulo, Brazil. Carn. Mus. Cat. No. 61.9251 (See also Pl. XXXV, figs. 7 and 8).

FIG. 1*a*. Adult female (No. 15), dorsal view (same specimen as that figured on Pl. XXXV, fig. 8).

FIG. 1*b*. Adult female (No. 15), inner view of left valve.

FIG. 1*c*. Adult female (No. 15), inner view of right valve.

FIG. 2. Half-grown, gravid female (No. 9), lateral view.

FIGS. 3–6. *Diplodon decipiens* Ortmann, from creek (tributary to Rio Iguassú), Serrinha, Paraná, Brazil. Carn. Mus. Cat. No. 61.9253.

FIG. 3*a*. Adult male (No. 4), lateral view.

FIG. 3*b*. Adult male (No. 4), inner view of left valve.

FIG. 3*c*. Adult male (No. 4), inner view of right valve.

FIG. 3*d*. Adult male (No. 4), dorsal view.

FIG. 4. Adult female (No. 6), lateral view.

FIG. 5. Half-grown, gravid female (No. 3), lateral view.

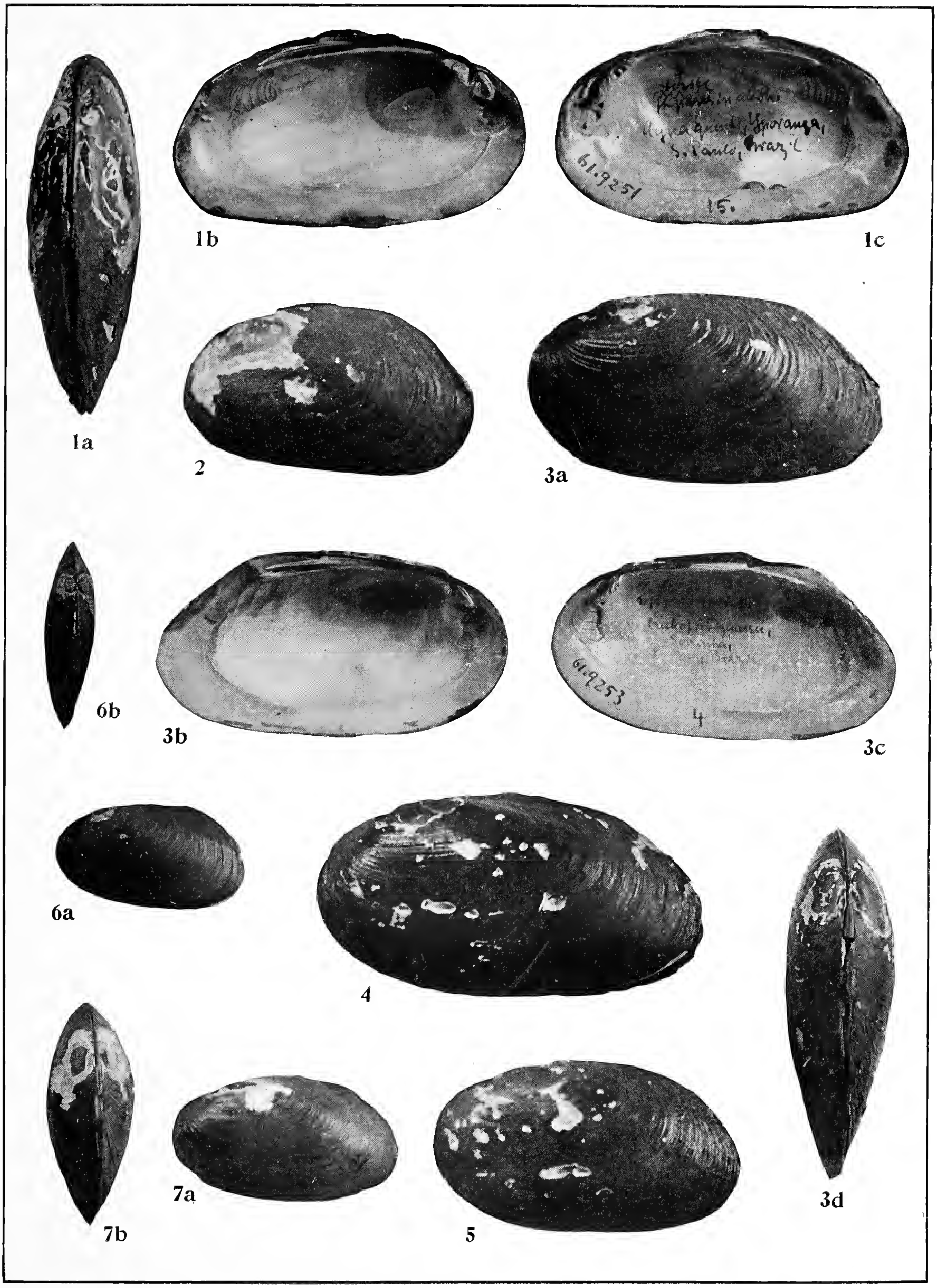
FIG. 6*a*. Young female (No. c), lateral view.

FIG. 6*b*. Young female (No. c), dorsal view.

FIG. 7. *Diplodon hildæ* Ortmann, from Rio Jacuhy, Cachoeira, Rio Grande do Sul, Brazil. Carn. Mus. Cat. No. 61.5864 (See also Pl. XXXVII, figs. 1–3).

FIG. 7*a*. Nearly full grown male (No. q), lateral view.

FIG. 7*b*. Nearly full grown male (No. q), dorsal view.




Diplodon.

## EXPLANATION OF PLATE XXXVII.

SHELLS OF DIPLODON HILDÆ ORTMANN AND DIPLODON MOGYMIRIM ORTMANN.

All figures natural size.

FIGS. 1–3. *Diplodon hildæ* Ortmann, from Rio Jacuhy, Cachoeira, Rio Grande do Sul, Brazil. Carn. Mus. Cat. No. 61.5864 (See also Pl. XXXVI, fig. 7).

FIG. 1*a*. Young male (No. d), lateral view.

FIG. 1*b*. Young male (No. d), dorsal view.

FIG. 2*a*. Adult female (No. 15), lateral view.

FIG. 2*b*. Adult female (No. 15), dorsal view.

FIG. 2*c*. Adult female (No. 15), inner view of left valve.

FIG. 2*d*. Adult female (No. 15), inner view of right valve.

FIG. 3. Half-grown female (No. *h*), lateral view.

FIGS. 4–7. *Diplodon mogymirim* Ortmann, from creek (tributary to Rio Mogy Guassú), Mogy Mirim, São Paulo, Brazil. Carn. Mus. Cat. No. 61.9260.

FIG. 4*a*. Adult male (No. 22), lateral view.

FIG. 4*b*. Adult male (No. 22), inner view of left valve.

FIG. 4*c*. Adult male (No. 22), inner view of right valve.

FIG. 5*a*. Half-grown male (No. 9), lateral view.

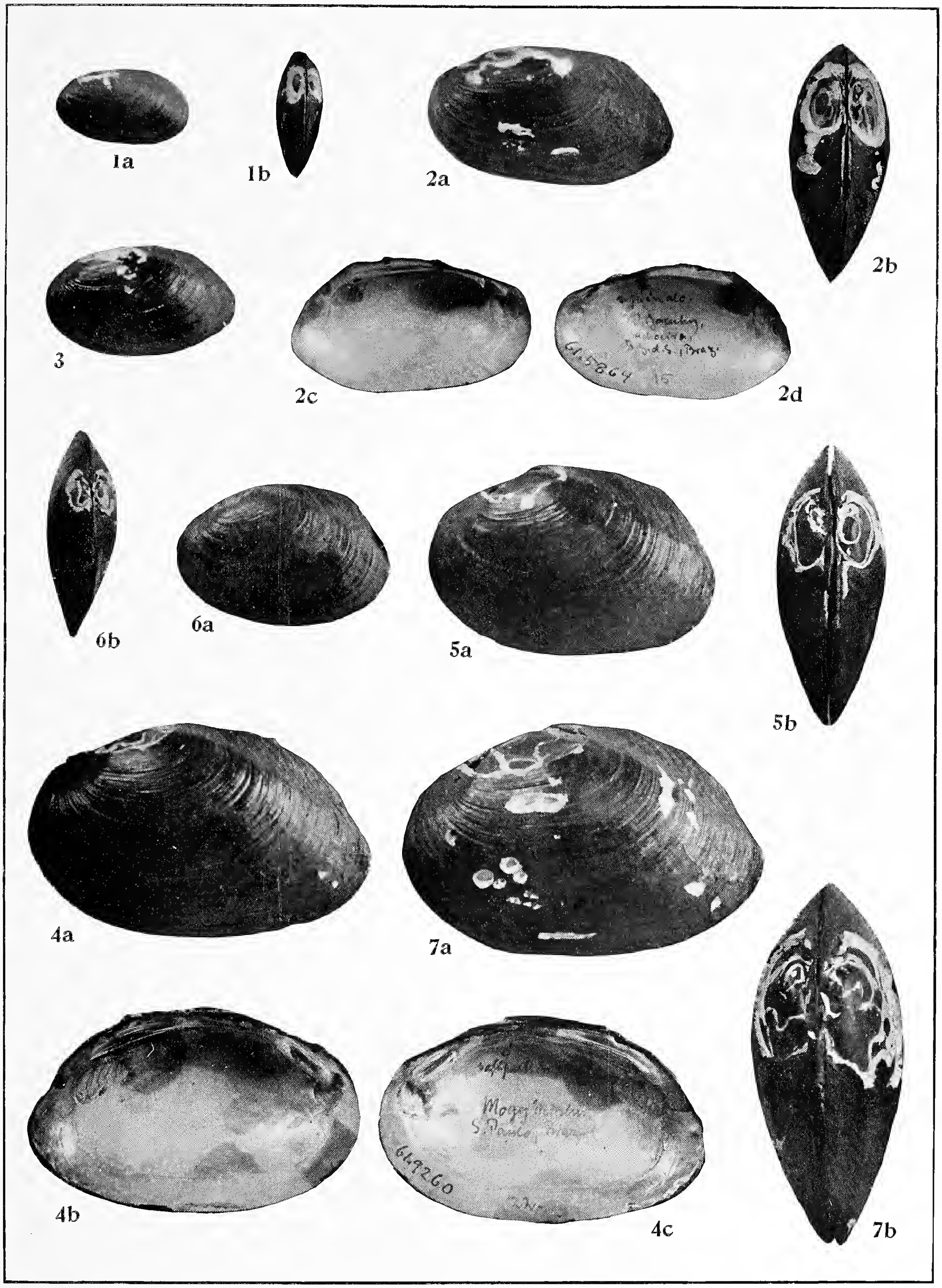
FIG. 5*b*. Half-grown male (No. 9), dorsal view.

FIG. 6*a*. Young male (No. 12), lateral view.

FIG. 6*b*. Young male (No. 12), dorsal view.

FIG. 7*a*. Adult female (No. 38), lateral view.

FIG. 7*b*. Adult female (No. 38), dorsal view.




Diplodon.

## EXPLANATION OF PLATE XXXVIII.

Shells of Diplodon berthæ Ortmann and Diplodon enno Ortmann.

All figures natural size.

Figs. 1–4. *Diplodon berthæ* Ortmann, from Rio Jacuhy, Cachoeira, Rio Grande do Sul, Brazil. Carn. Mus. Cat. No. 61.5865.

Fig. 1*a*. Adult male (No. 24), lateral view.

Fig. 1*b*. Adult male (No. 24), dorsal view.

Fig. 1*c*. Adult male (No. 24), inner view of left valve.

Fig. 1*d*. Adult male (No. 24), inner view of right valve.

Fig. 2*a*. Young male (No. 3), lateral view.

Fig. 2*b*. Young male (No. 3), dorsal view.

Fig. 3*a*. Gravid female (No. 10), lateral view.

Fig. 3*b*. Gravid female (No. 10), dorsal view.

Fig. 4. Gravid female (No. 16), lateral view.

Figs. 5–8. *Diplodon enno* Ortmann, from Rio Grande (São Francisco drainage), Boqueirão, Bahia, Brazil. Carn. Mus. Cat. No. 61.9264.

Fig. 5. Half-grown male (No. 4), lateral view.

Fig. 6*a*. Young male (No. 12), lateral view.

Fig. 6*b*. Young male (No. 12), dorsal view.

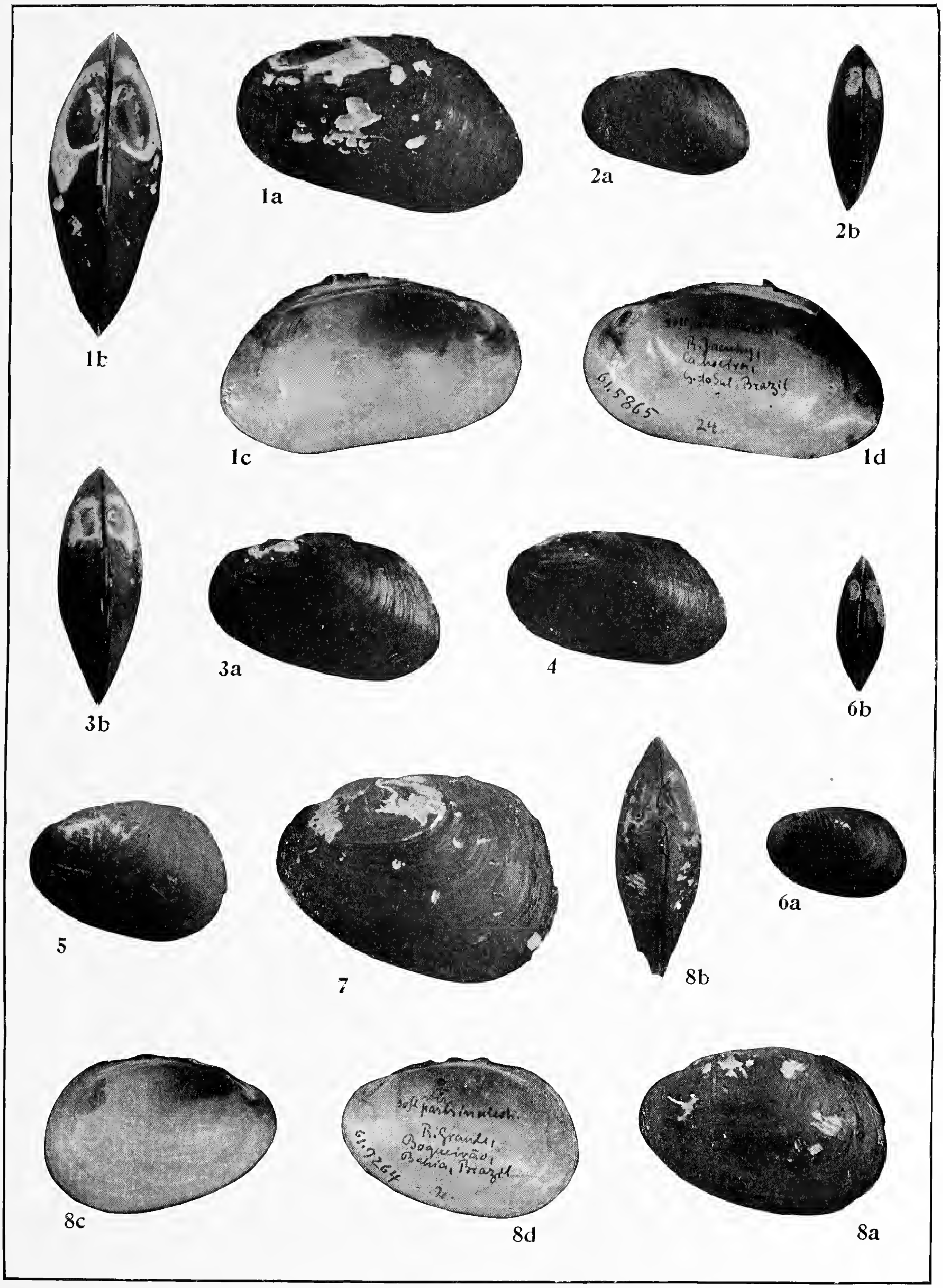
Fig. 7. Adult female (No. 1), lateral view.

Fig. 8*a*. Nearly adult female (No. 2), lateral view.

Fig. 8*b*. Nearly adult female (No. 2), dorsal view.

Fig. 8*c*. Nearly adult female (No. 2), inner view of left valve.

Fig. 8*d*. Nearly adult female (No. 2), inner view of right valve.




DIPLODON.

## EXPLANATION OF PLATE XXXIX.

SHELLS OF DIPLODON DECEPTUS (SIMPSON), DIPLODON (CYCLOMYA) PARANENSIS (LEA), AND CASTALIA UNDOSA VON MARTENS.

All figures natural size.

FIGS. 1–5. *Diplodon deceptus* (Simpson), from Rio Jacuhy, Cachoeira, Rio Grande do Sul, Brazil. Carn. Mus. Cat. No. 61.5868.

FIG. 1*a*. Adult male (No. 10), lateral view.

FIG. 1*b*. Adult male (No. 10), dorsal view.

FIG. 1*c*. Adult male (No. 10), inner view of left valve.

FIG. 1*d*. Adult male (No. 10), inner view of right valve.

FIG. 2. Adult male (No. 11), lateral view.

FIG. 3. Half-grown male (No. 4), lateral view.

FIG. 4. Half-grown female (No. 6), lateral view.

FIG. 5*a*. Young specimen (sex ?) (No. 2), lateral view.

FIG. 5*b*. Young specimen (sex ?) (No. 2), dorsal view.

FIGS. 6 AND 7. *Diplodon* (*Cyclomya*) *paranensis* (Lea).

FIG. 6. Nearly adult female (No. a), lateral view, from Rio de la Plata, San Isidro, Argentina. Carn. Mus. Cat. No. 61.9265.

FIG. 7. Young specimen, lateral view, from Rio Paraguay, Corumba, Matto Grosso, Brazil. Carn. Mus. Cat. No. 61.2031.

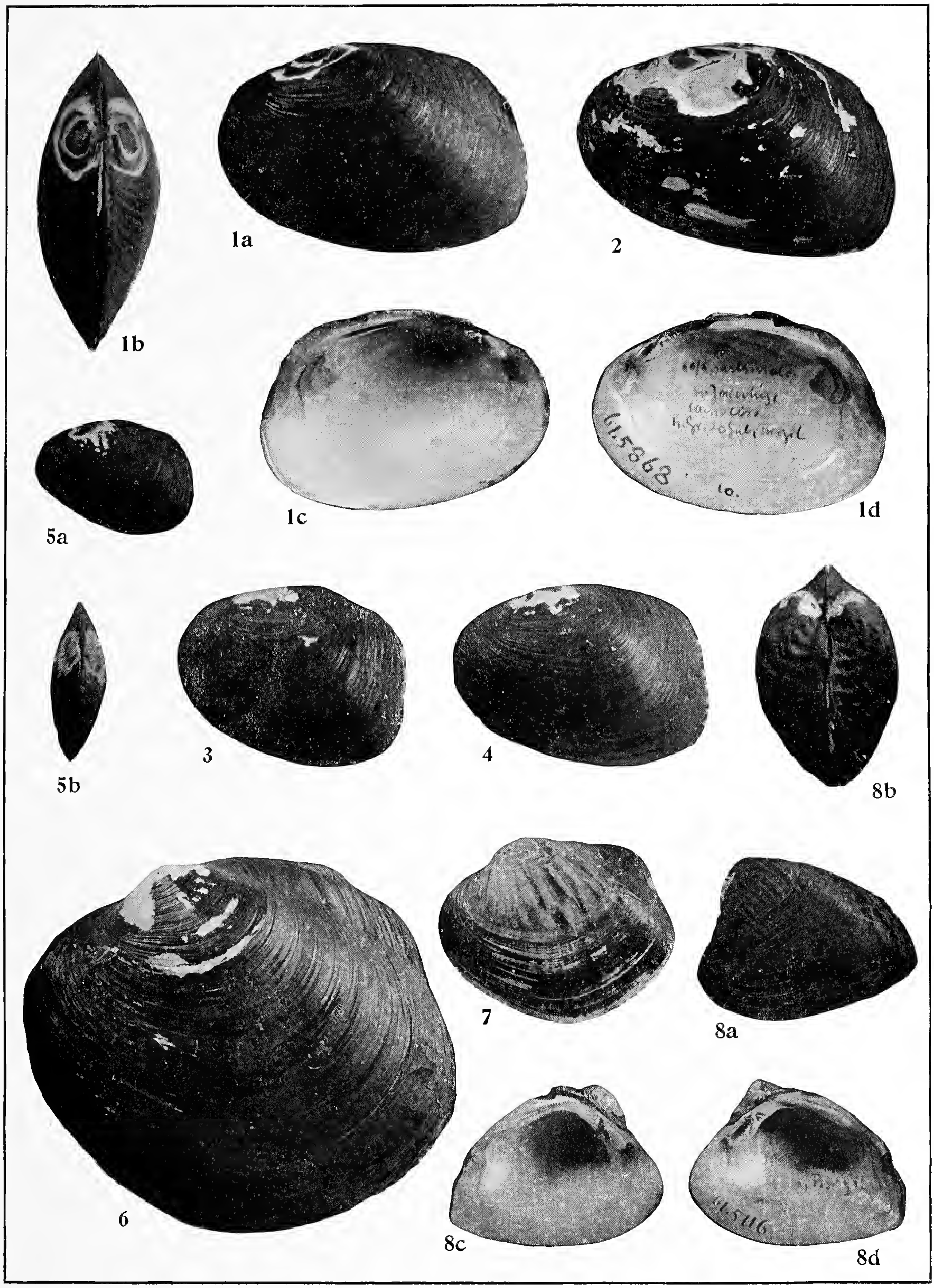
FIG. 8. *Castalia undosa* Von Martens, from Rio Tieté, Itapura, São Paulo, Brazil. Carn. Mus. Cat. No. 61.5116.

FIG. 8*a*. Half-grown specimen, lateral view.

FIG. 8*b*. Half-grown specimen, dorsal view.

FIG. 8*c*. Half-grown specimen, inner view of left valve.

FIG. 8*d*. Half-grown specimen, inner view of right valve.




DIPLODON and CASTALIA.

## EXPLANATION OF PLATE XL.

Shells of Prisodon alatus (Sowerby), Monocondylæa obesa Ortmann, and Anodontites crispata Bruguière.

All figures natural size.

Figs. 1–3. *Prisodon alatus* (Sowerby), from Rio Tapajos, Santarem, Para, Brazil. Carn. Mus. Cat. No. 61.5109.

Fig. 1. Adult specimen, lateral view.

Fig. 2*a*. Half-grown specimen, lateral view.

Fig. 2*b*. Half-grown specimen, dorsal view.

Fig. 2*c*. Half-grown specimen, inner view of left valve.

Fig. 2*d*. Half-grown specimen, inner view of right valve.

Fig. 3. Young specimen, lateral view.

Figs. 4–6. *Monocondylæa obesa* Ortmann, from Rio Tapajos, Santarem, Para, Brazil. Carn. Mus. Cat. No. 61.5850.

Fig. 4*a*. Half-grown specimen (No. 10), lateral view.

Fig. 4*b*. Half-grown specimen (No. 10), inner view of left valve.

Fig. 4*c*. Half-grown specimen (No. 10), inner view of right valve.

Fig. 5*a*. Young specimen (No. 5), lateral view.

Fig. 5*b*. Young specimen (No. 5), dorsal view.

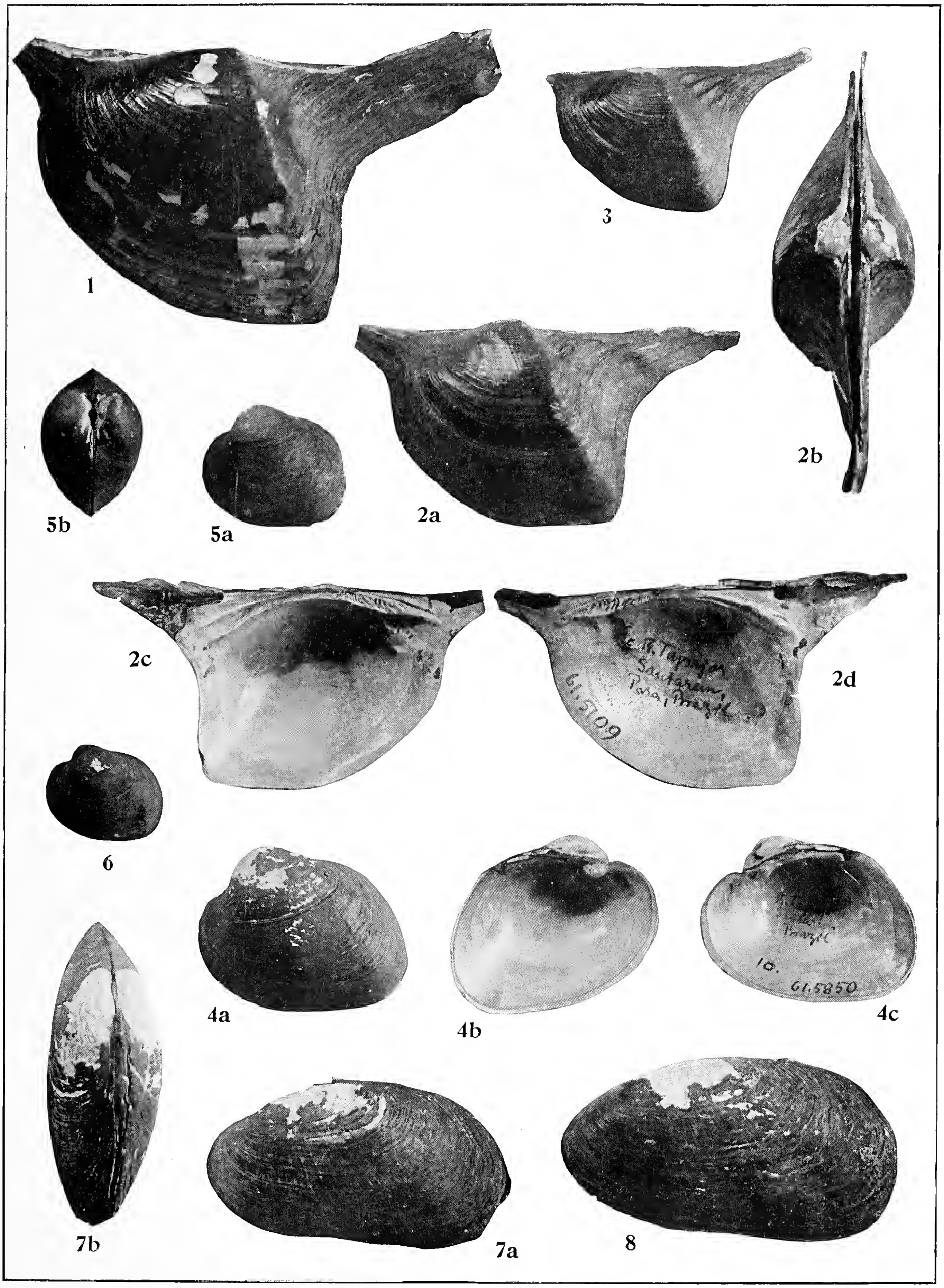
Fig. 6. Young specimen (No. 1), lateral view.

Figs. 7 and 8. *Anodontites crispata* Bruguière, from Rio de la Paila, Paila, U. S. of Colombia. Carn. Mus. Cat. No. 61.9274 (See also Plate XLI, figs. 2 and 3).

Fig. 7*a*. Half-grown male (No. 8), lateral view.

Fig. 7*b*. Half-grown male (No. 8), dorsal view.

Fig. 8. Nearly adult female (No. 10), lateral view.




Prisodon, Monocondylæa, Anodontites.

## EXPLANATION OF PLATE XLI.

Shells of Monocondylaea hollandi Ortmann, Anodontites crispata Brugière, and Anodontites clessini (Fischer).

All figures natural size.

Fig. 1. *Monocondylæa hollandi* Ortmann, from Rio Guaporé, near Rio São Simão, Matto Grosso, Brazil. Carn. Mus. Cat. No. 61.5846.

Fig. 1*a*. Holotype, male, lateral view.

Fig. 1*b*. Holotype, male, dorsal view.

Fig. 1*c*. Holotype, male, inner view of right valve.

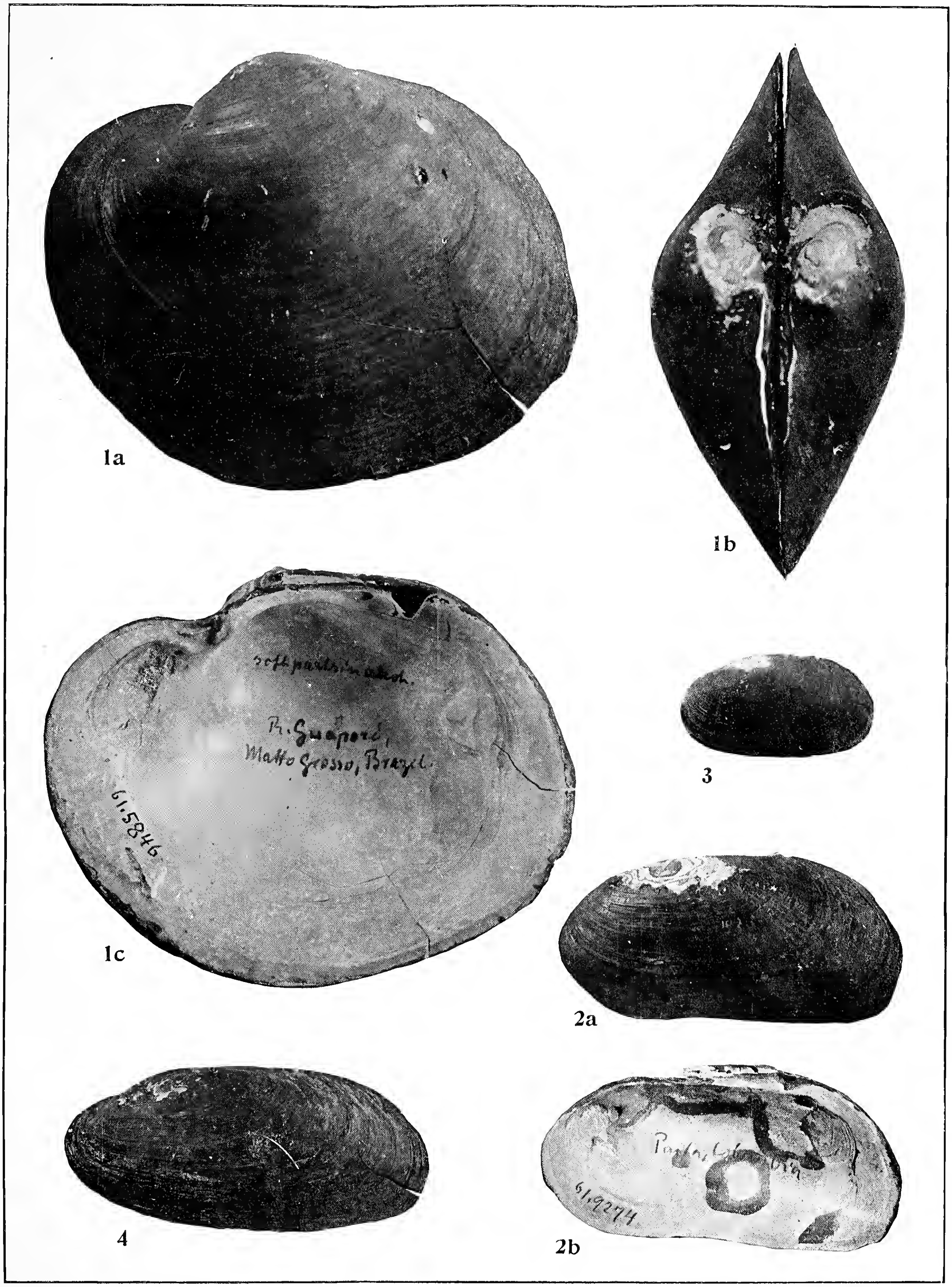
Figs. 2 and 3. *Anodontites crispata* Bruguière, from Rio de la Paila, Paila, U. S. of Colombia. Carn. Mus. Cat. No. 61.9274 (See also Plate XL, figs. 7 and 8).

Fig. 2*a*. Nearly adult specimen (sex ?), lateral view.

Fig. 2*b*. Nearly adult specimen (sex ?), inner view of right valve.

Fig. 3. Young specimen (sex ?), lateral view.

Fig. 4. *Anodontites clessini* (Fischer), from Rio Vaccahy-mirim, Santa Maria, Rio Grande do Sul, Brazil. Carn. Mus. Cat. No. 61.5820 (See also Plate XLII, figs. 1 and 2). Male (No. 12), lateral view (See also Plate XLII, fig. 1).




MONOCONDYLÆA, ANODONTITES.

## EXPLANATION OF PLATE XLII.

SHELLS OF ANODONTITES CLESSINI (FISCHER), ANODONTITES HYRIOIDES ORTMANN, ANODONTITES HASEMANI ORTMANN, AND ANODONTITES IHERINGI (CLESSIN).

All figures natural size.

FIGS. 1 AND 2. *Anodontites clessini* (Fischer), from Rio Vaccahy-mirim, Santa Maria, Rio Grande do Sul, Brazil. Carn. Mus. Cat. No. 61.5820 (See also Plate XLI, fig. 4).

FIG. 1. Male (No. 12), dorsal view (Same specimen as that figured on Pl. XLI, fig. 4).

FIG. 2*a*. Female (No. 11), lateral view.

FIG. 2*b*. Female (No. 11), inner view of right valve.

FIGS. 3–5. *Anodontites hyrioides* Ortmann, from Rio Tapajos, Santarem, Para, Brazil. Carn. Mus. Cat. No. 61.5829.

FIG. 3*a*. Largest specimen (No. 6), lateral view.

FIG. 3*b*. Largest specimen (No. 6), inner view of right valve.

FIG. 4*a*. Half-grown specimen (No. 4), lateral view.

FIG. 4*b*. Half-grown specimen (No. 4), dorsal view.

FIG. 5. Young specimen (No. 1), lateral view.

FIGS. 6 AND 7. *Anodontites hasemani* Ortmann, from Rio Paraguay, Santa Rita, Matto Grosso, Brazil. Carn. Mus. Cat. No. 61.5832.

FIG. 6*a*. Half-grown male (No. 1), lateral view.

FIG. 6*b*. Half-grown male (No. 1), inner view of left valve.

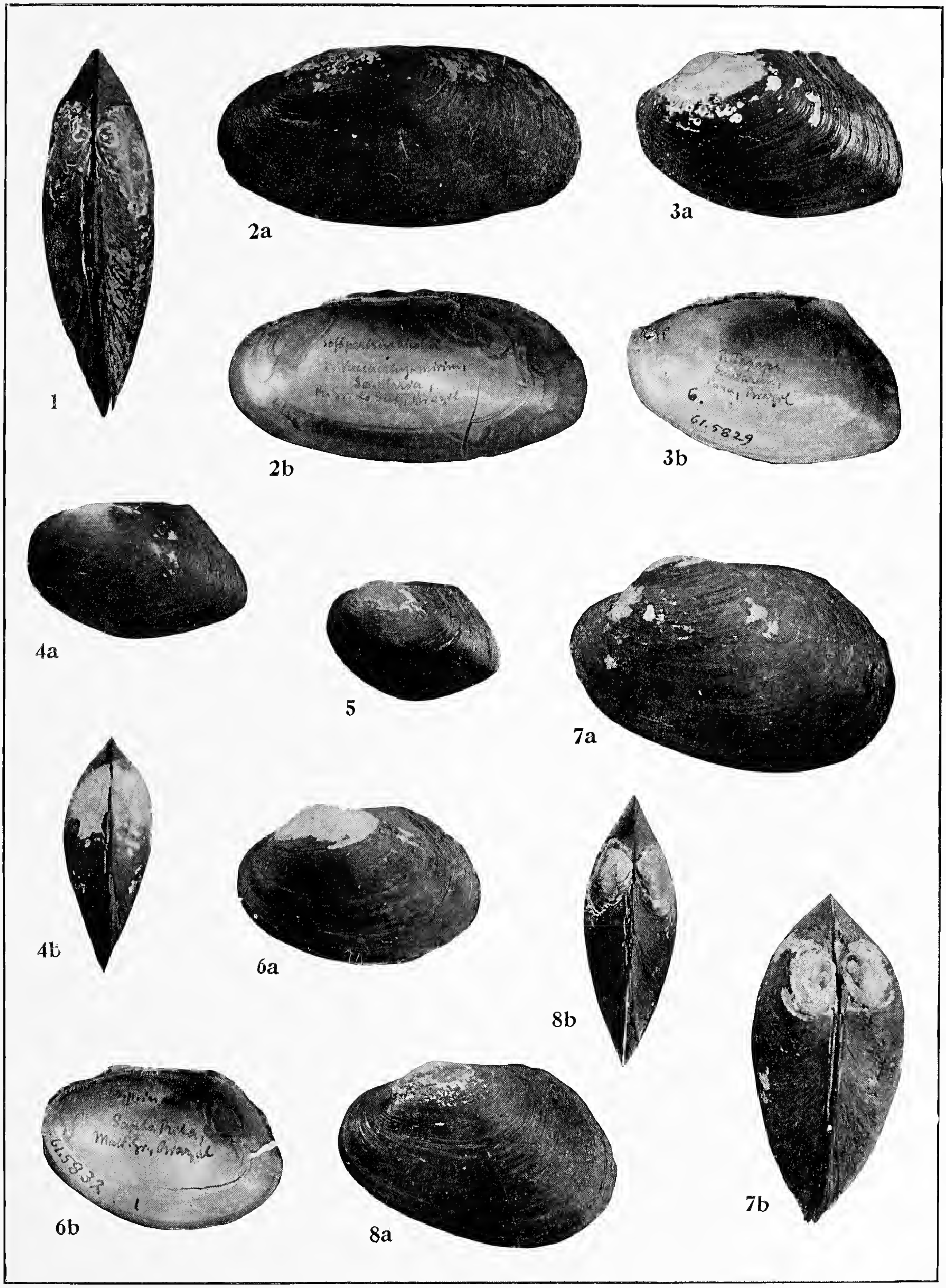
FIG. 7*a*. Gravid female (No. 3), lateral view.

FIG. 7*b*. Gravid female (No. 3), dorsal view.

FIG. 8. *Anodontites iheringi* (Clessin), from Rio Vaccahy-mirim, Santa Maria, Rio Grande do Sul, Brazil. Carn. Mus. Cat. No. 61.5815 (See also Plate XLIII, fig. 1, and Plate XLIV, fig. 1).

FIG. 8*a*. Half-grown male (No. 1), lateral view.

FIG. 8*b*. Half-grown male (No. 1), dorsal view.




ANODONTITES.

## EXPLANATION OF PLATE XLIII.

SHELLS OF ANODONTITES IHERINGI (CLESSIN), ANODONTITES RIOGRANDENSIS (VON IHERING), AND ANODONTITES FORBESIANA (LEA).

All figures natural size.

FIG. 1. *Anodontites iheringi* (Clessin), from Vaccahy-mirim, Santa Maria, Rio Grande do Sul, Brazil. Carn. Mus. Cat. No. 61.5815 (See also Plate XLII, fig. 8, and Plate XLIV, fig. 1).

Adult female (No. 3), lateral view (See also Plate XLIV, fig. 1).

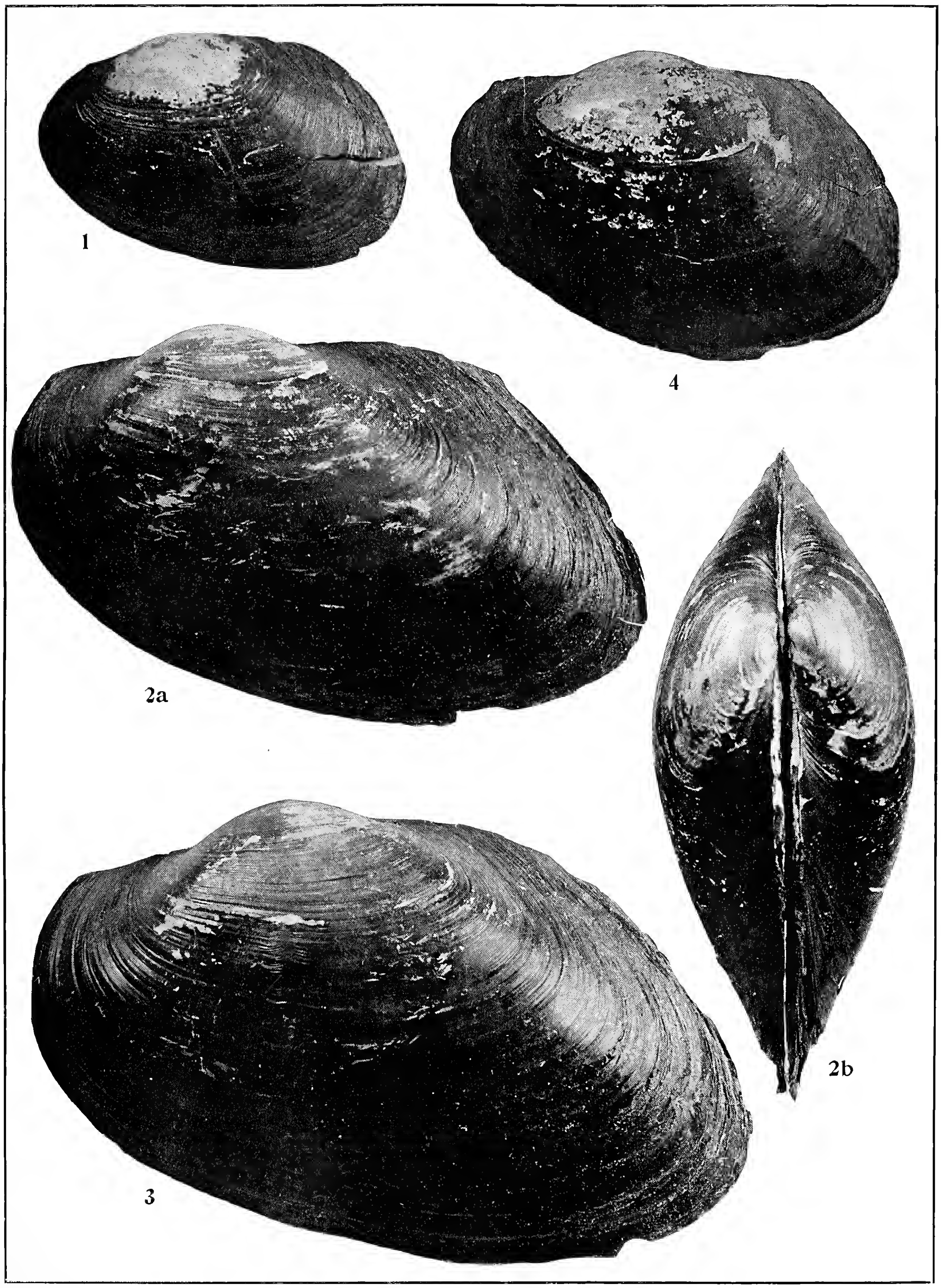
FIGS. 2 AND 3. *Anodontites riograndensis* (Von Ihering), from Rio de la Plata, San Isidro, Argentina. Carn. Mus. Cat. No. 61.9279 (See also Plate XLIV, fig. 2).

FIG. 2*a*. Adult male (No. x), lateral view.

FIG. 2*b*. Adult male (No. x), dorsal view.

FIG. 3. Adult, gravid female (No. z), lateral view (See also Plate XLIV, fig. 2).

FIG. 4. *Anodontites forbesiana* (Lea), from Rio Uruguay, Uruguayana, Rio Grande do Sul, Brazil. Carn. Mus. Cat. No. 61.9280 (See also Plate XLIV, fig. 3). Half-grown male (No. 8), lateral view.




ANODONTITES.

## EXPLANATION OF PLATE XLIV.

SHELLS OF ANODONTITES IHERINGI (CLESSIN), ANODONTITES RIOGRANDENSIS (VON IHERING), AND ANODONTITES FORBESIANA (LEA).

All figures natural size.

FIG. 1. *Anodontites iheringi* (Clessin), from Rio Vaccahy-mirim, Santa Maria, Rio Grande do Sul, Brazil. Carn. Mus. Cat. No. 61.5815 (See also Plate XLII, fig. 8, and Plate XLIII, fig. 1). Adult female (No. 3), inner view of right valve (Same specimen as that figured on Plate XLIII, fig. 1).

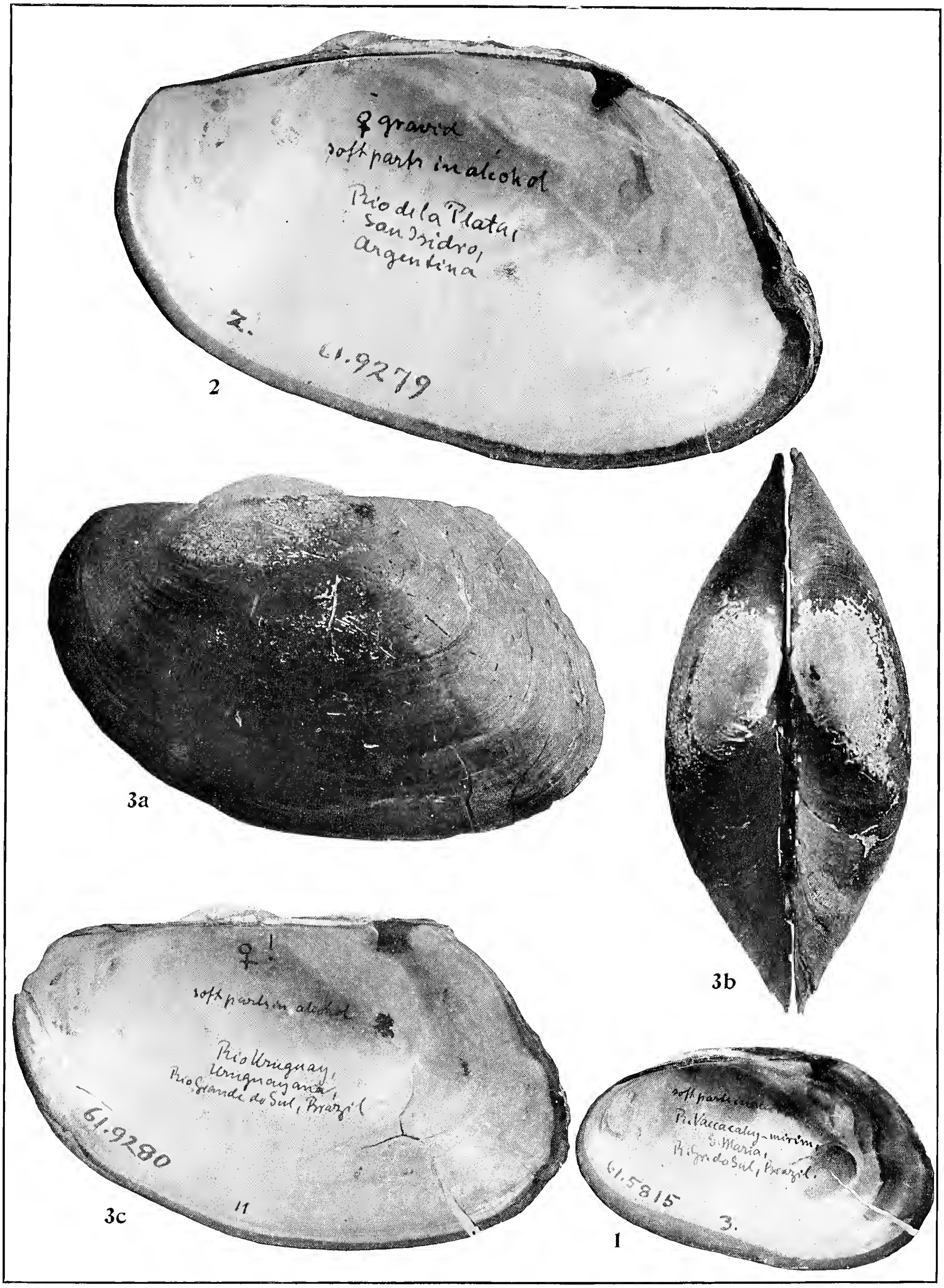
FIG. 2. *Anodontites riograndensis* (Von Ihering), from Rio de la Plata, San Isidro, Argentina, Carn. Mus. Cat. No. 61.9279 (See also Plate XLIII, figs. 2 and 3). Adult, gravid female (No. z), inner view of right valve (Same specimen as that figured on Plate XLIII, fig. 3).

FIG. 3. *Anodontites forbesiana* (Lea), from Rio Uruguay, Uruguayana, Rio Grande do Sul, Brazil. Carn. Mus. Cat. No. 61.9280 (See also plate XLIII, fig. 4).

FIG. 3*a*. Nearly adult female (No. 11), lateral view.

FIG. 3*b*. Nearly adult female (No. 11), dorsal view.

FIG. 3*c*. Nearly adult female (No. 11), inner view of right valve.




Anodontites.

## EXPLANATION OF PLATE XLV.

GILLS OF DIPLODON IMITATOR ORTMANN, DIPLODON SIMILLIMUS ORTMANN, DIPLODON VICARIUS ORTMANN, AND DIPLODON DECIPIENS ORTMANN.

All figures represent the left gills magnified to twice natural size, the inner gill to the left, the outer gill to the right.

FIG. 1. *Diplodon imitator* Ortmann, from Rio Vaccahy-mirim, Santa Maria, Rio Grande do Sul, Brazil. Carn. Mus. Cat. No. 61.9248.

FIG. 1*a*. Gills of male (No. 29) (Shell of this specimen figured on Plate XXXIV, fig. 5).

FIG. 1*b*. Gills of female (No. 32).

FIG. 2. *Diplodon simillimus* Ortmann, from Rio Nhundiaquara, Morretes, Paraná, Brazil. Carn. Mus. Cat. No. 61.9250.

FIG. 2*a*. Gills of male (No. 7).

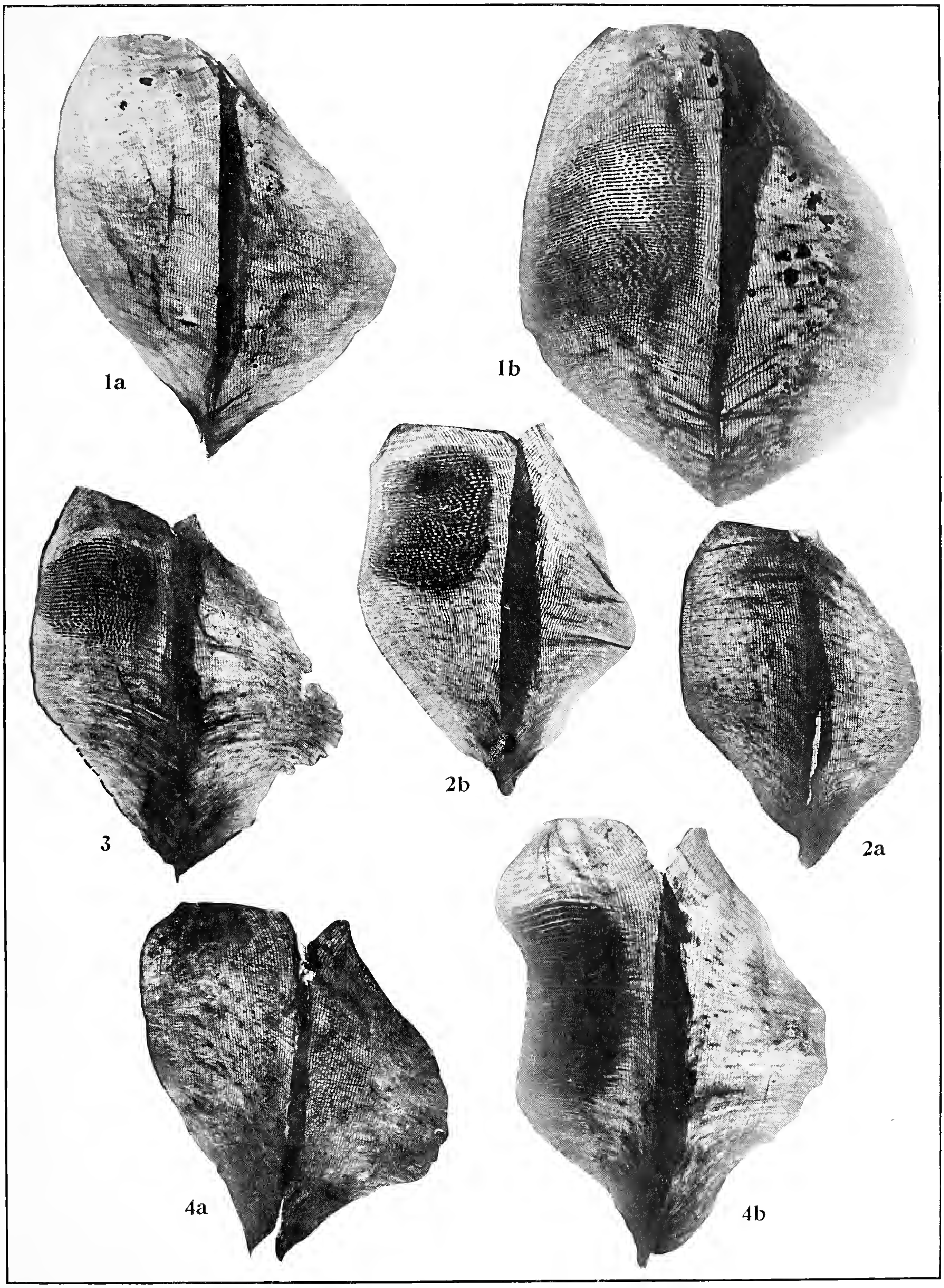
FIG. 2*b*. Gills of female (No. 23).

FIG. 3. *Diplodon vicarius* Ortmann, from creek (Rio Ribeira drainage), Aqua Quente, near Iporanga, São Paulo, Brazil. Carn. Mus. Cat. No. 61.9251. Gills of female (No. 14).

FIG. 4. *Diplodon decipiens* Ortmann, from creek (tributary to Rio Iguassú), Serrinha, Paraná, Brazil. Carn. Mus. Cat. No. 61.9253.

FIG. 4*a*. Gills of male (No. 2).

FIG. 4*b*. Gills of female (No. 6) (Shell of this specimen figured on Plate XXXVI, fig. 4).




ANATOMY OF DIPLODON.

## EXPLANATION OF PLATE XLVI.

GILLS OF DIPLODON PAULISTA (VON IHERING), DIPLODON PICEUS (LEA), DIPLODON HILDÆ ORTMANN, DIPLODON BURROUGHIANUS (LEA), DIPLODON MOGYMIRIM ORTMANN, DIPLODON BERTHÆ ORTMANN, AND DIPLODON ENNO ORTMANN.

All figures represent left gills magnified to twice natural size, the inner gill to the left, the outer gill to the right.

FIG. 1. *Diplodon paulista* (Von Ihering), from Rio Tieté, Mogy das Cruzes, São Paulo, Brazil. Carn. Mus. Cat. No. 61.9294. Gills of female (No. 4).

FIG. 2. *Diplodon piceus* (Lea), from Rio Uruguay, Uruguayana, Rio Grande do Sul, Brazil. Carn. Mus. Cat. No. 61.5862. Gills of female (No. 7).

FIG. 3. *Diplodon hildæ* Ortmann, from Rio Jacuhy, Cachoeira, Rio Grande do Sul, Brazil. Carn. Mus. Cat. No. 61.5864. Gills of female (No. 15) (Shell of this specimen figured on Plate XXXVII, fig. 2).

FIG. 4. *Diplodon burroughianus* (Lea), from pond along Rio Negro, Santa Isabel, Uruguay. Carn. Mus. Cat. No. 61.5859. Gills of female (No. x).

FIG. 5. *Diplodon mogymirim* Ortmann, from creek (tributary to Rio Mogy Guassú) Mogy Mirim, São Paulo, Brazil. Carn. Mus. Cat. No. 61.9260.

FIG. 5*a*. Gills of male (No. 28).

FIG. 5*b*. Gills of young female (No. 18).

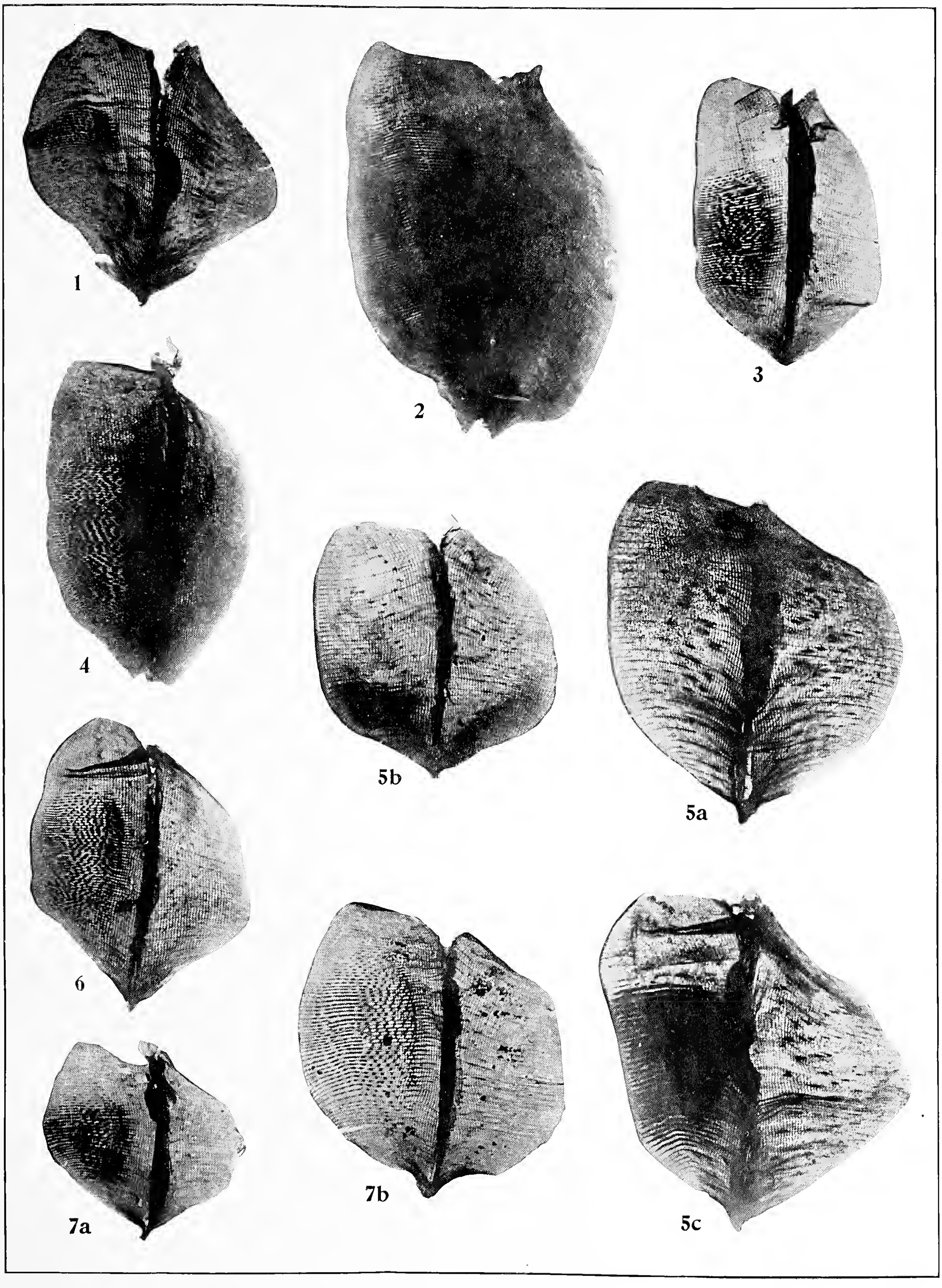
FIG. 5*c*. Gills of adult female (No. 44).

FIG. 6. *Diplodon berthæ* Ortmann, from Rio Jacuhy, Cachoeira, Rio Grande do Sul, Brazil. Carn. Mus. Cat. No. 61.5865. Gills of female (No. 21).

FIG. 7. *Diplodon enno* Ortmann, from Rio Grande (São Francisco drainage), Boqueirão, Bahia, Brazil. Carn. Mus. Cat. No. 61.9264.

FIG. 7*a*. Gills of young female (No. 7).

FIG. 7*b*. Gills of nearly adult female (No. 2) (Shell of this specimen figured on Plate XXXVIII, fig. 8).




ANATOMY OF DIPLODON.

## EXPLANATION OF PLATE XLVII.

Left gills of Diplodon deceptus (Simpson), Castalla nehringi Von Ihering, and right gills of Monocondylæa lentiformis Lea and Anodontites clessini (Fischer); twice natural size; inner gill to the left, outer gill to the right (Figs. 1–4).

Horizontal sections of gills of Diplodon hasemani Ortmann, Diplodon imitator Ortmann, and Diplodon decipiens Ortmann; much enlarged; inner gill to the left, outer gill to the right (Figs. 5–7).

Fig. 1. *Diplodon deceptus* (Simpson), from Rio Jacuhy, Cachoeira, Rio Grande do Sul, Brazil. Carn. Mus. Cat. 61.5868. Gills of female (No. 9).

Fig. 2. *Castalina nehringi* Von Ihering. from Rio Tieté, Itapura, São Paulo, Brazil. Carn. Mus. Cat. No. 61.5120. Gills of half-grown female (No. 1).

Fig. 3. *Monocondylæa lentiformis* Lea, from Rio Uruguay, Uruguayana, Rio Grande do Sul, Brazil. Carn. Mus. Cat. No. 61.5841.

Fig. 3*a*. Gills of male (No. 1).

Fig. 3*b*. Gills of female (No. 4).

Fig. 4. *Anodontites clessini* (Fischer), from Rio Vaccahy-mirim, Santa Maria, Rio Grande do Sul, Brazil. Carn. Mus. Cat. No. 61.5820.

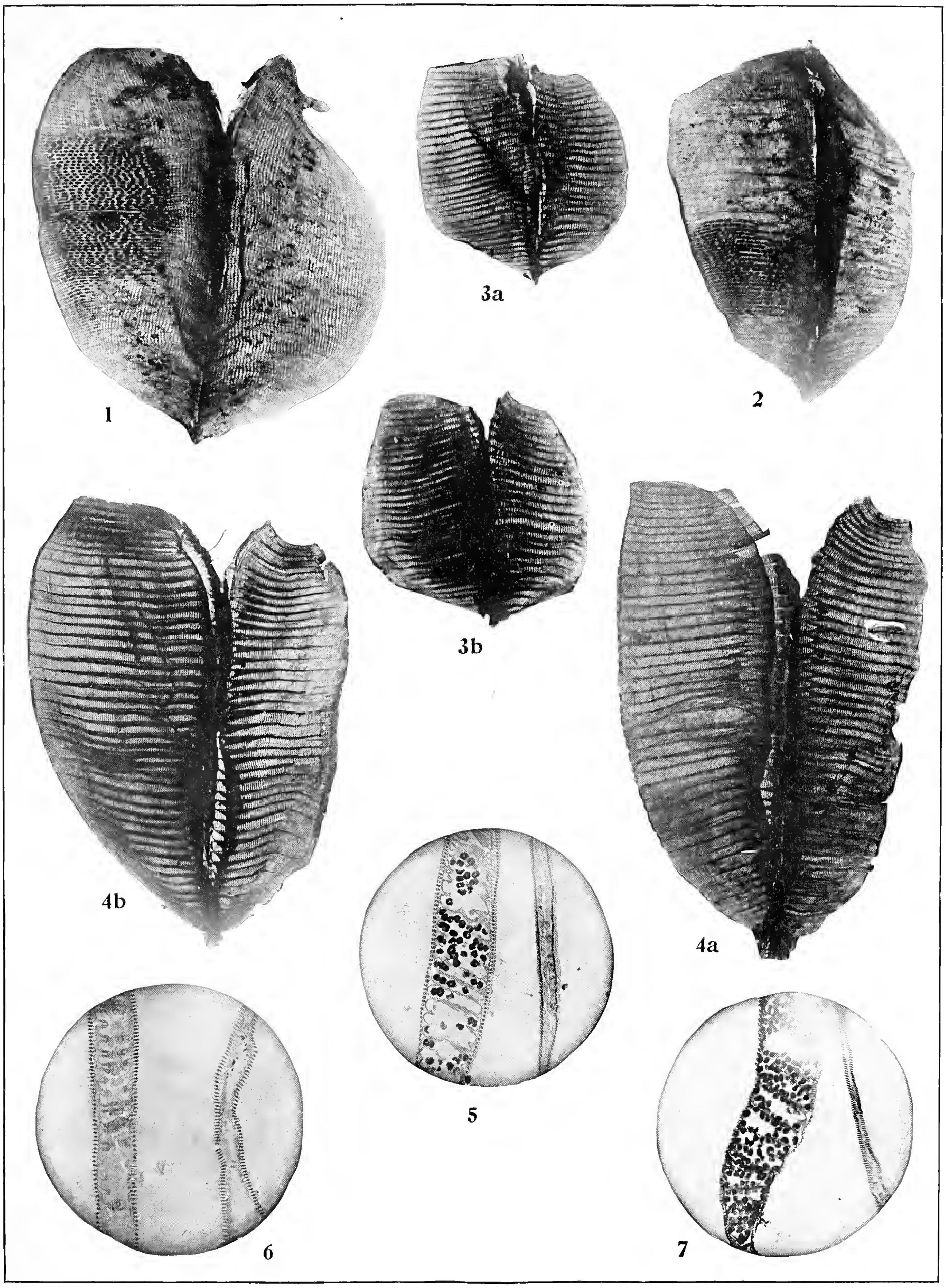
Fig. 4*a*. Gills of male (No. 12) (Shell of this specimen figured on Plate XLI, fig. 4, and Plate XLII, fig. 1).

Fig. 4*b*. Gills of female (No. 11) (Shell of this specimen figured on Plate XLII, fig. 2).

Fig. 5. *Diplodon hasemani* Ortmann, from Rio Guaporé, near Rio São Simão, Matto Grosso, Brazil, Carn. Mus. Cat. No. 61.5857. Section of gills of gravid female (No. 5).

Fig. 6. *Diplodon imitator* Ortmann, from Rio Vaccahy-mirim, Santa Maria, Rio Grande do Sul, Brazil. Carn. Mus. Cat. No. 61.9284. Section of gills of female (No. 33) (Shell of this specimen figured on Plate XXIV, fig. 7).

Fig. 7. *Diplodon decipiens* Ortmann, from creek (tributary to Rio Iguassú), Serrinha, Paraná, Brazil. Carn. Mus. Cat. No. 61.9253. Section of gills of gravid female (No. 5).




ANATOMY OF DIPLODON, CASTALIA, MONOCONDYLÆA, ANODONTITES.

## EXPLANATION OF PLATE XLVIII.

Horizontal sections of gills of Diplodon paulista (Von Ihering), Diplodon mogymirim Ortmann, Diplodon gratus (Lea), Diplodon deceptus (Simpson), Castalina nehringi Von Ihering, Fossula fossiculifera (D'Orbigny), Monocondylæa minuana D'Orbigny, and Anodontites patagonica rubicunda (Lea); much enlarged; inner gill to the left, outer gill to the right.

Fig. 1. *Diplodon paulista* (Von Ihering), from creek (tributary to Rio Mogy Guassú), Mogy Mirim, São Paulo, Brazil. Carn. Mus. Cat. No. 61.9256. Section of gills of gravid female (No. 3).

Fig. 2. *Diplodon mogymirim* Ortmann, from creek (tributary to Rio Mogy Guassú), Mogy Mirim, São Paulo, Brazil. Carn. Mus. Cat. No. 61.9260.

Fig. 2*a*. Section of gills of female (No. 45).

Fig. 2*b* Section of gills of gravid female (No. 4).

Fig. 3. *Diplodon gratus* (Lea), from Rio Uruguay, Uruguayana, Rio Grande do Sul, Brazil. Carn. Mus. Cat. No. 61.5866.

Fig. 3*a*. Section of gills of male (No. 19).

Fig. 3*b*. Section of gills of female (No. 20).

Fig. 4. *Diplodon deceptus* (Simpson), from Rio Jacuhy, Cachoeira, Rio Grande do Sul, Brazil. Carn. Mus. Cat. No. 61.5868. Section of gills of half-grown female (No. 6) (Shell of this specimen figured on Plate XXXIX, fig. 4).

Fig. 5. *Castalina nehringi* Von Ihering, from Rio Tieté, Itapura, São Paulo, Brazil. Carn. Mus. Cat. No. 61.5120. Section of gills of gravid female (No. 5).

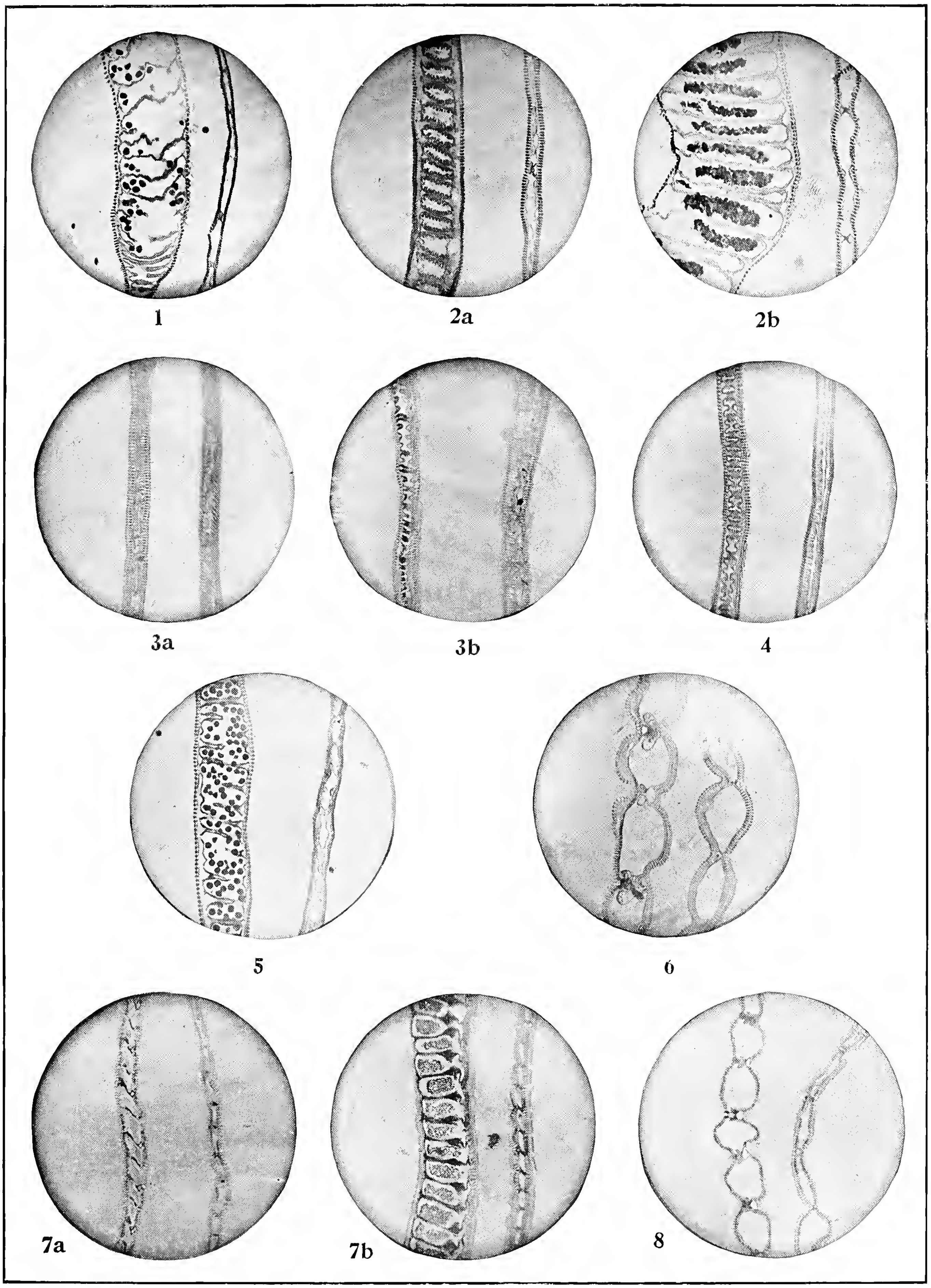
Fig. 6. *Fossula fossiculifera* (D'Orbigny), from Rio Tieté, Itapura, São Paulo, Brazil. Carn. Mus. Cat. No. 61.5840. Section of gills of female.

Fig. 7. *Monocondylæa minuana* D'Orbigny, from Rio Uruguay, Uruguayana, Rio Grande do Sul, Brazil. Carn. Mus. Cat. No. 61.5848.

Fig. 7*a*. Section of gills of male (No. 5).

Fig. 7*b*. Section of gills of gravid female (No. 6).

Fig. 8. *Anodontites patagonica rubicunda* (Lea), from Rio Cacequy, Cacequy, Rio Grande do Sul, Brazil. Carn. Mus. Cat. No. 61.5810. Section of gills of female.




ANATOMY OF DIPLODON, CASTALINA, FOSSULA, MONOCONDYLÆA, and ANODONTITES.

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